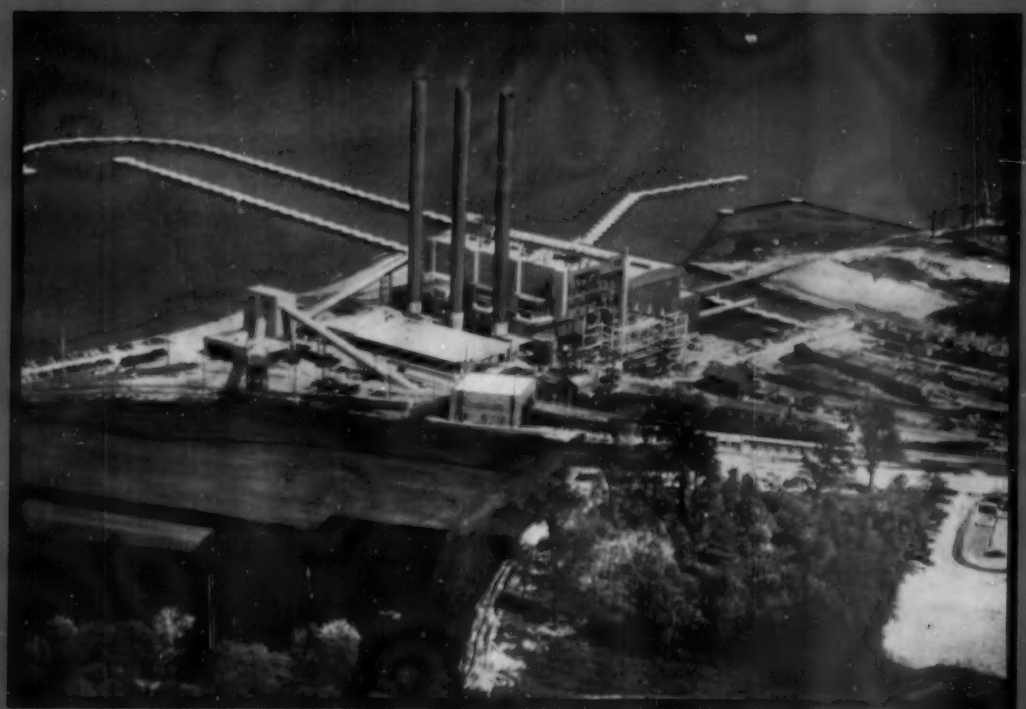
COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

March 1955



Eastlake Plant of the Cleveland Electric Illuminating Company

Eastlake Plant Features

Problems In Feedwater Deaeration

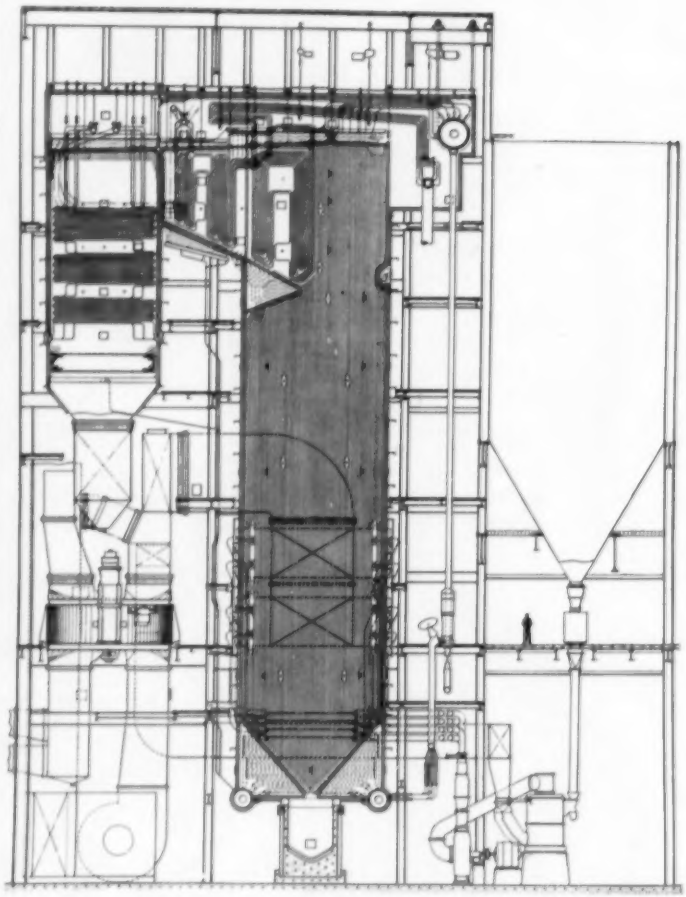
Research in the Power Industry

High Temperature Water Heating

GALLATIN STEAM PLANT

Tennessee Valley Authority

C-E controlled circulation boilers



The C-E Unit shown above is one of two duplicates now under construction for the Gallatin Steam Plant of the Tennessee Valley Authority at Gallatin, Tennessee.

Each of these units is designed to serve a 250,000-kw turbine-generator operating at a throttle pressure of 2000 psi with a primary steam temperature of 1053 F, reheated to 1053 F.

They are of the controlled-circulation, radiant type with a separated furnace arrangement. Secondary superheater surface is at the outlet of one furnace and reheater surface at the outlet of the other. Primary superheater sections and economizer surface follow both the secondary superheater and reheater surfaces. Regenerative air heaters follow the economizer surfaces. The section shown above is taken through the superheater furnace.

Pulverized coal firing is employed, using bowl mills and tilting, tangential burners. Natural gas may be used as an alternate fuel.

B-805

C-E

COMBUSTION ENGINEERING, INC.

Combustion Engineering Building
200 Madison Avenue, New York 16, N. Y.

BOILERS, FUEL BURNING & RELATED EQUIPMENT; PULVERIZERS, AIR SEPARATORS & FLASH DRYING SYSTEMS; PRESSURE VESSELS; AUTOMATIC WATER HEATERS; SOIL PIPE

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

Vol. 25 **No. 9**

March 1955

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BPA

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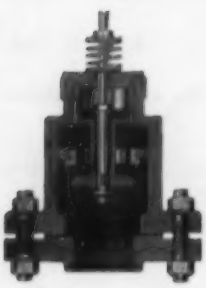
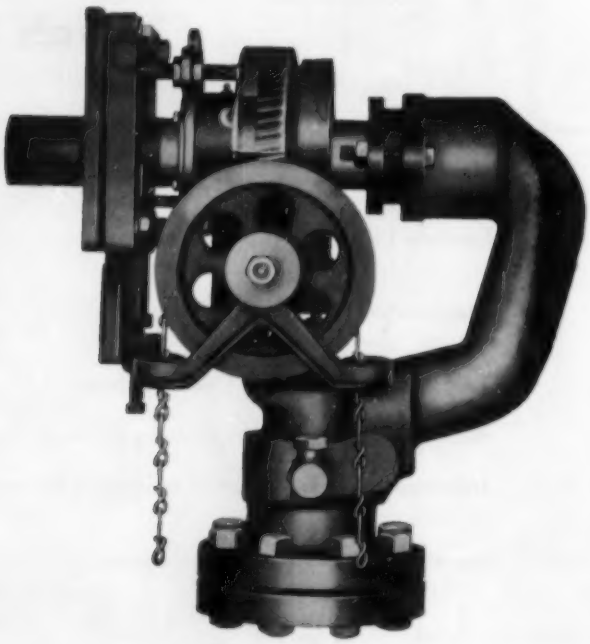
BAYER
STEPS UP BOILER PERFORMANCE

DISTINCTLY DIFFERENT



Bayer Balanced Valves are famous for their long life and continued tightness.



Bayer Single Chain Balanced Valve Soot Cleaner.

WITH THE Bayer Balanced Valve Soot Cleaner the balancing chamber above the piston disc impounds steam when the valve closes, thus relieving valve parts from shock. The valves remain ***steam tight*** because the dashpot action causes the valve to seat gently. Unbalanced valves close with a hammer stroke and soon become leaky.

When stationary elements are used the Bayer stationary balanced valve head may be furnished. Thus all the cleaning elements of the entire soot cleaner system can be controlled by the Bayer quick-opening Balanced valves. This gives a uniform or standard valve controlled system and in addition, when high pressures require a reduction in pressure ***at each individual element*** this Balanced valve unit, whether used with a stationary or a revolving element, can be fitted with an integral orifice plate valve.

Piping connections can be kept in the same plane and undesirable bends or fittings avoided when the Bayer Balanced Valve is installed with both stationary and revolving elements.

Valve parts are standard and interchangeable and when high pressure heads are fitted with orifice plate regulating valves these parts are also interchangeable.

THE BAYER COMPANY

SAINT LOUIS, MISSOURI, U. S. A.

. . . One leading public utility has a 4,500 psi, 1,150F double reheat cycle unit under construction. Another announced plans for a new supercritical pressure, steam electric station. The single-boiler-turbine-generator unit for this new station will operate at a higher steam temperature and pressure, and will have a capability greater than any installation thus far announced. Using supercritical pressure, and employing two stages of reheat, the new unit should be the most efficient plant thus far projected by the central station industry. The 6,000-psi steam generator will supply steam to the turbine at 5,000 psi, 1,200F. . . .

AS POWER PIPING BECOMES MORE CRITICAL

M. W. KELLOGG TESTING TECHNIQUES KEEP PACE

To meet the demand for more electric power, and to increase output with the least possible increase in fuel, the trend in utility steam power plants, as reported everywhere, is to higher temperatures and pressures. Thus steam piping—main and reheat—becomes even more critical than before.

One way in which The M. W. Kellogg Company, leading fabricator of power piping, keeps pace with increases in temperature, pressure, and capacity demands is in its testing techniques. Most recent Kellogg development is the company's "atomic camera". Activated by isotopes such as cobalt, iridium, and cesium, this powerful and portable device can photograph welded seams up to six inches thick in a single, short exposure. The same test by traditional X-ray equipment would take considerably longer.

The M. W. Kellogg Company was among the first to be permitted by the AEC to use isotopes of this magnitude. The atomic camera has already proved its value in the construction of many important public utility jobs. It is indicative of the Kellogg research and engineering which guard the vital link between steam power plant boilers and turbines.

M. W. KELLOGG'S "ATOMIC CAMERA"

FABRICATED PRODUCTS DIVISION
THE M. W. KELLOGG COMPANY, 225 BROADWAY, NEW YORK 7, N. Y.
The Canadian Kellogg Company, Ltd., Toronto • Kellogg International Corp., London
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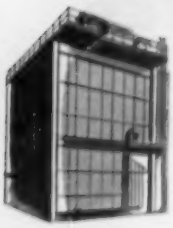
POWER PIPING—THE VITAL LINK

In the 267 new **central station units being started in 40 different states during the 1953-56 period, 75% of the**

 **boilers will be equipped with Consolidated Maxiflow Safety Valves**

...35% will also have Consolidated Electromatic Relief Valves. These bulletins

tell you why.

Consolidated Maxiflow Safety Valve BULLETIN 707 contains data about the greater discharge capacity, permanent tightness and easily controlled blowdown that make this valve outstanding in safety and service.

Consolidated Electromatic Relief Valve BULLETIN 720 tells how this valve assures (1) more accurately balanced boiler operation; (2) more uniform line pressure; (3) power conservation; (4) less maintenance of spring-loaded safety valves; (5) greater protection against overheating your superheater; (6) increased efficiency for your steam generating plant.

Both bulletins give complete specifications. Write for copies.

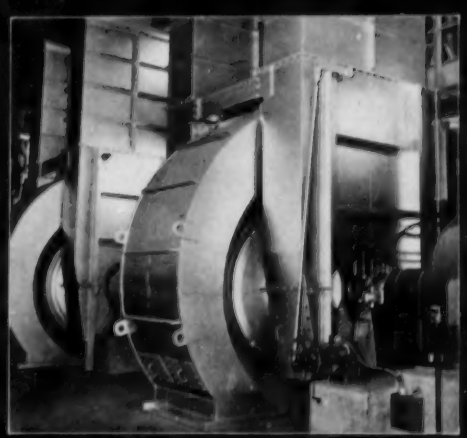
CONSOLIDATED SAFETY VALVES

A product of **MANNING, MAXWELL & MOORE, INC.** STRATFORD, CONN.

MAKERS OF 'CONSOLIDATED' SAFETY AND RELIEF VALVES, 'AMERICAN' AND 'AMERICAN-MICROSEN' INDUSTRIAL INSTRUMENTS, 'HANCOCK' VALVES, 'ASHCROFT' GAUGES, AIRCRAFT PRODUCTS. BUILDERS OF "SHAW-BOX" AND 'LOAD LIFTER' CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES.

Fact:

Westinghouse Design 14 Compressors Engineered to Handle Any Job— 500 to 200,000 cfm at Pressures up to 110" w.g. (4 psi)



Design 14 Compressors operate in parallel with either motor or turbine drive.

WIDE RANGE OF APPLICATION IN POWER GENERATION AND INDUSTRY

Here is a line of centrifugal compressors for wide application.

In the power field, they provide economical forced draft for pressurized and cyclone furnaces.

Industrial uses include such varied applications as combustion, catalyst conveying, scavenging, flotation, aeration of liquids and many others.

These compressors maintain constant pressure over a wide range of air output—also available with adjustable inlet Spin Control for economical part load operation.

QUIET OPERATION—

Casing proportions and streamlined wheel passages make Westinghouse Design 14 Compressors inherently quiet. Accessory sound-absorbing trunks of proved design available to reduce noise level even further where required because of location.

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Call your nearest Westinghouse-Sturtevant Sales Engineer . . . he's the "Man with the Facts" on heating, air handling, and electronic air cleaning . . . or fill in the coupon below.

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Please send more information on your Design 14 Compressors.

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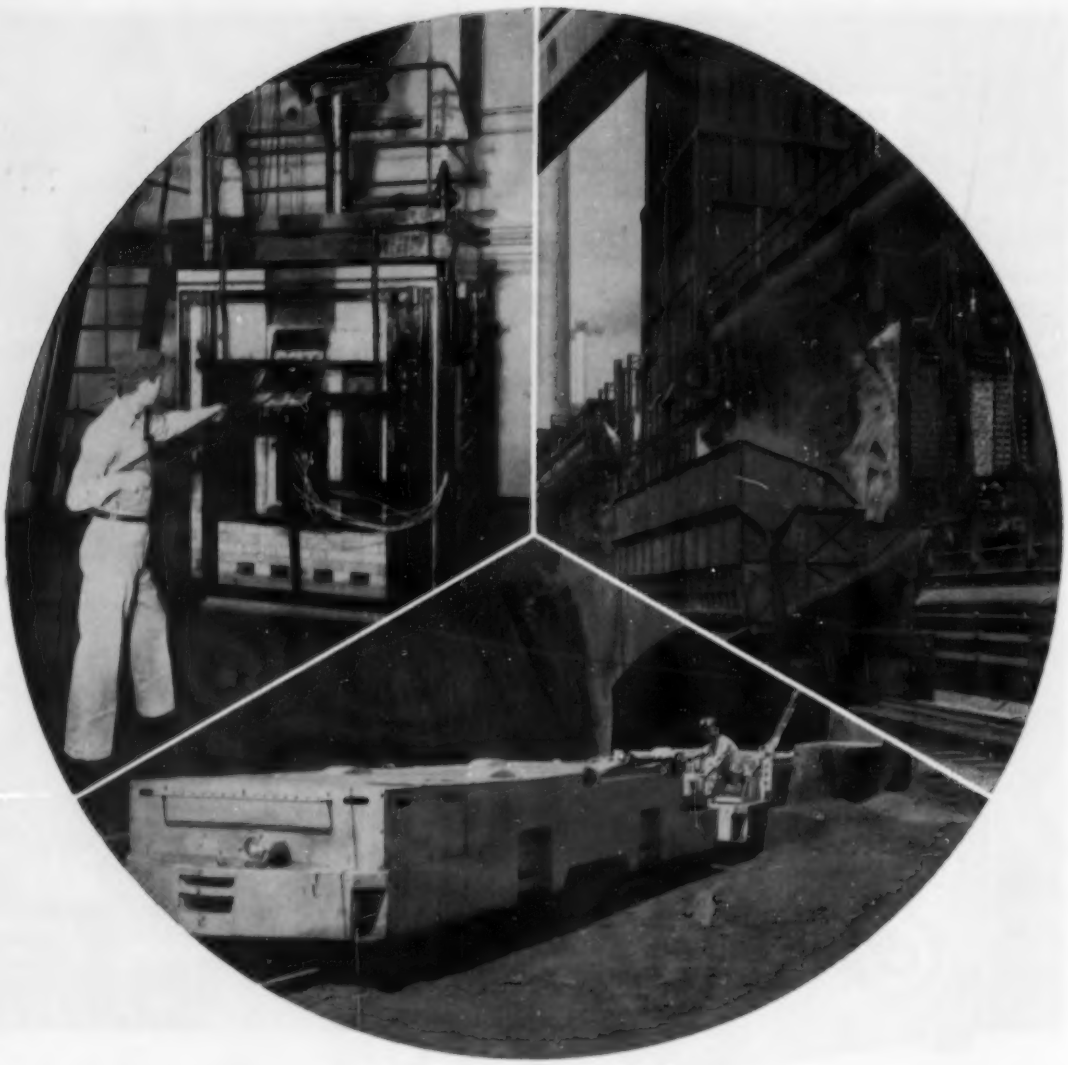
COMPANY .....

CITY .....STATE.....



BEACON COKING COALS

Produced by Coke Oven Operators

Here are some facts that may interest you—as a coke plant operator—when you are thinking about your source of supply for coking coals.

We have been large-scale coke producers for many years, and know coke oven problems and coking coal needs.

We maintain a modern laboratory for coal and coke research, and verify laboratory findings in actual plant operations.

We operate the mines that supply us with the kinds of coking coals that our research and our experience have proven most desirable.

Doesn't it stand to reason that coking coals produced by those mines should have something a little *extra*-special to offer for coke plant use?

And doesn't it stand to reason that YOU could benefit by buying these coals for your own ovens?

It looks that way to us. We hope it looks that way to YOU, too.

EASTERN GAS AND FUEL ASSOCIATES — BEACON COAL

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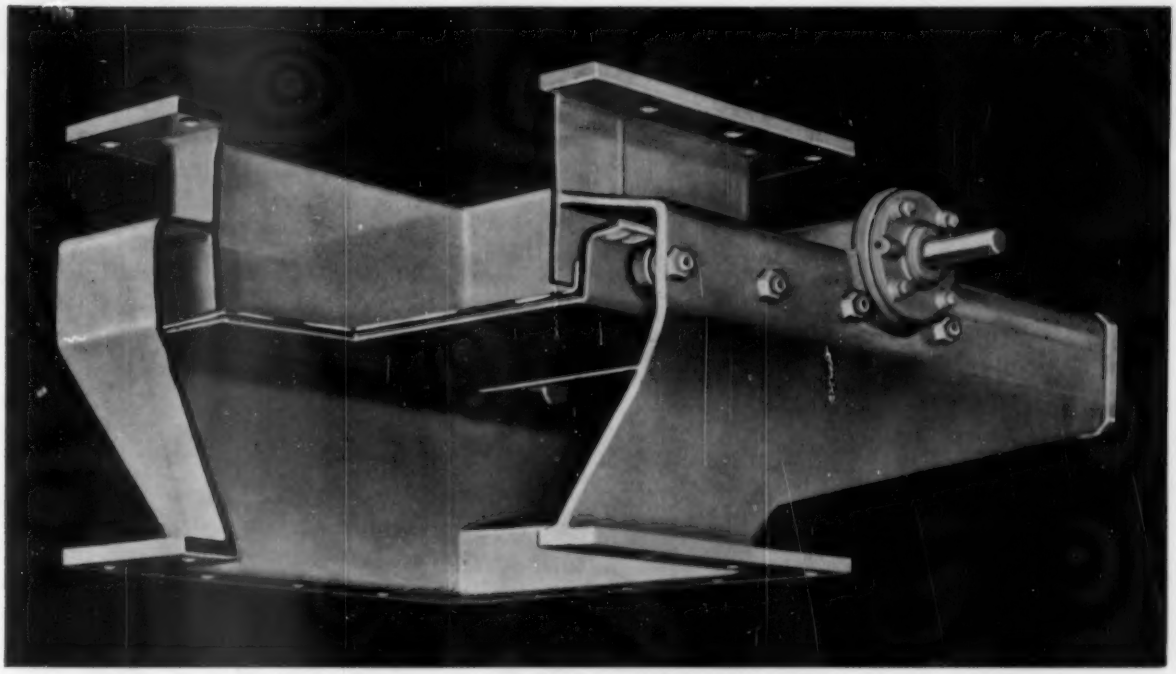


Here's The Inside Story On The New
S-E-CO. Coal Valve

Strip the ⅜" steel skin off our new coal valve and you'll quickly see why *you get more when you buy S-E-Co.*

First, notice the deep U-shaped gate which completely shields rollers, racks and pinions from coal flow. See how the gate provides lap closure on all four sides assuring positive cut-off. Also, note the stainless steel liner on top side of the gate to combat corrosion.

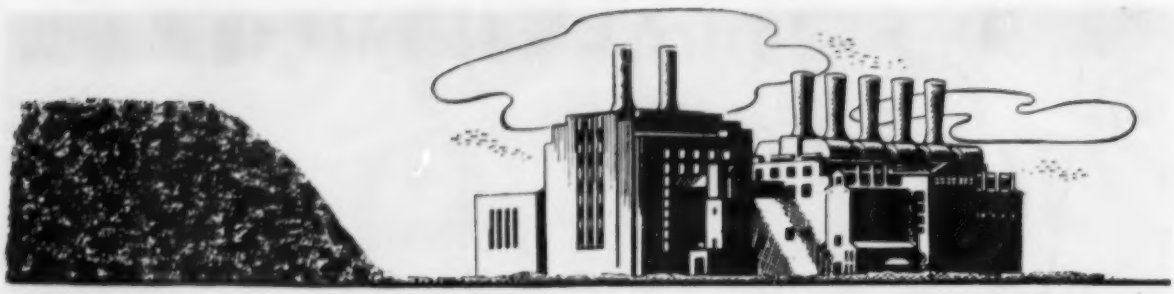
Carefully formed ladder racks, for their part, are self-cleaning having no root portion in which coal dust can build up and cause jamming. The multi-faced pinions, located above the racks, are also of self-cleaning design. Consequently, the gate moves smoothly with little effort, even after long periods of not being operated.

Notice the clean interior design. Slopes have been kept at a maximum with shoulders and projections eliminated. Even the poke hole covers fit flush with the inside of the valve body so that nothing interferes with flow of coal through the valve.

For a complete list of all the outstanding features of the new S-E-Co. Coal Valve together with installation photographs and dimensions, write for Bulletin No. 97.

STOCK Equipment Company

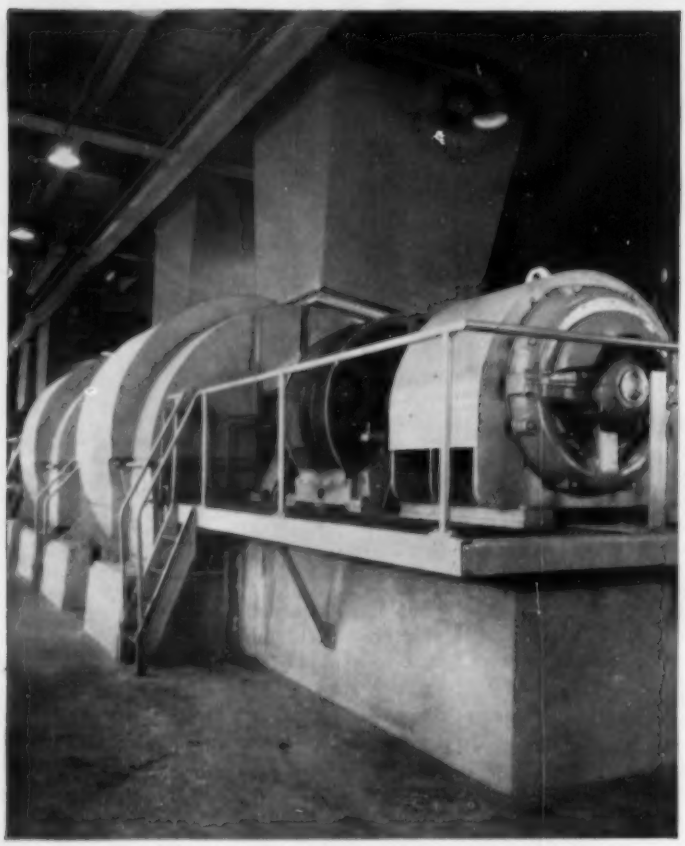
745-C, HANNA BLDG., CLEVELAND 15, OHIO



YOUR AIR SUPPLY MUST BE DEPENDABLE, TOO!

SPECIFY "BUFFALO" DRAFT FANS

FOR DELIVERY YOU CAN COUNT ON



The modern "Buffalo" Induced Draft Fan provides stable performance over a wide range of loads in today's high-resistance boiler systems. Its modified radial blade medium speed design, with low velocity through rotor and housing, is especially suited to counteract the severe abrasive action of hot fly-ash.

Since air is as important to combustion as fuel, why take a chance on your draft? "Buffalo" Mechanical Draft has more than earned its reputation for reliability over half a century in many of the biggest utility stations and plant boiler rooms. That's due to the "Buffalo" "Q" Factor*, the standard we've always held to: "build it up to the job, not down to a price." And users have reaped the benefits of longer fan service, fewer draft timeouts, easier maintenance — cheaper power output. "Buffalo" Induced Draft Fans, Forced Draft Fans, Primary Air Fans, Overfire Blowers and Diesel scavenger Fans are ready to do the same for you, too.

Write today for Bulletin 3750 for valuable engineering advice and facts on the fans for your power job!

**The "Q" Factor — the built-in Quality which provides trouble-free satisfaction and long life.*

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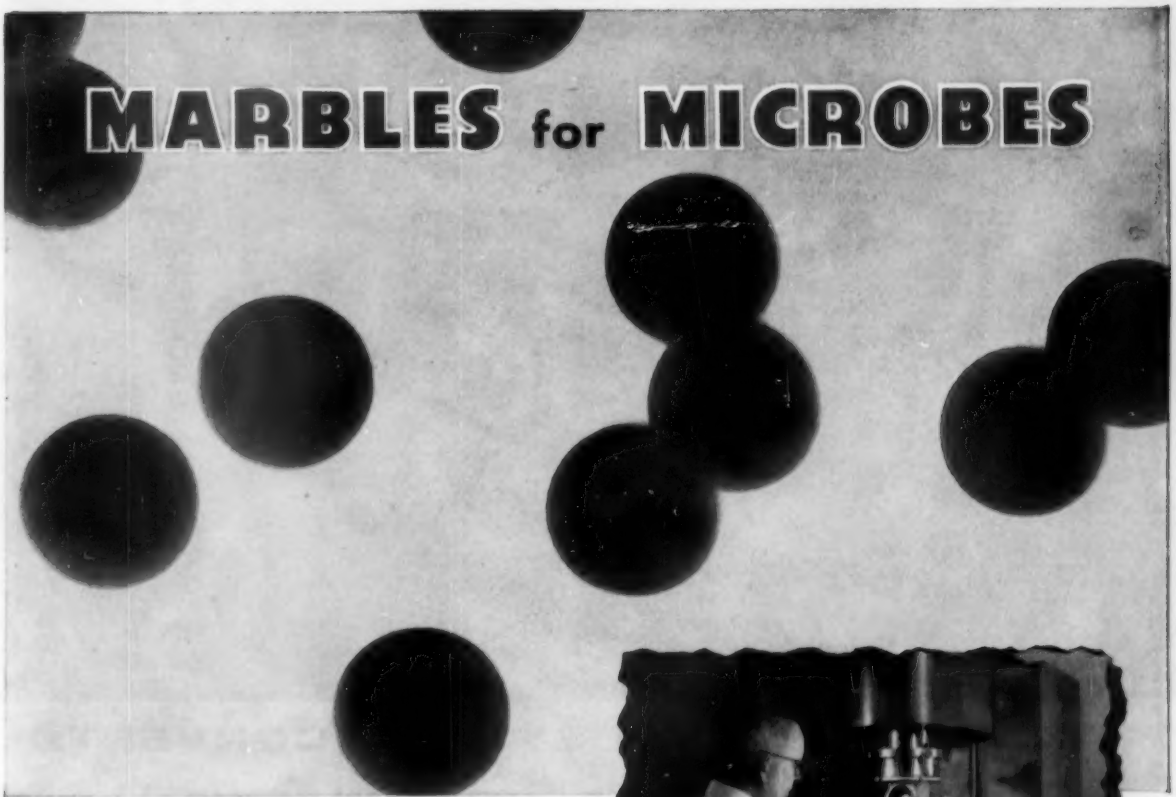
VENTILATING AIR CLEANING AIR TEMPERING INDUCED DRAFT EXHAUSTING FORCED DRAFT COOLING HEATING PRESSURE BLOWING

MARBLES for MICROBES



Above—100,000X enlargement of latex spheres used to calibrate electron microscope in Nalco Laboratories. Actual diameter of spheres is 0.25 microns—.00000975 inches! *Right*—Inserting specimen holder in vacuum chamber of Nalco electron microscope.

. . . How they assist research toward better Water Treatment

PERHAPS even too small to make good marbles for microbes, these tiny spheres help Nalco Scientists in their investigations of the microscopic realms of matter only recently made visible to the human eye by the electron microscope.

Use of the electron microscope in water treatment research is significant because it typifies the continuing efforts of the entire Nalco organization to keep the Nalco System representative of the first and best in all phases of modern industrial water treatment.

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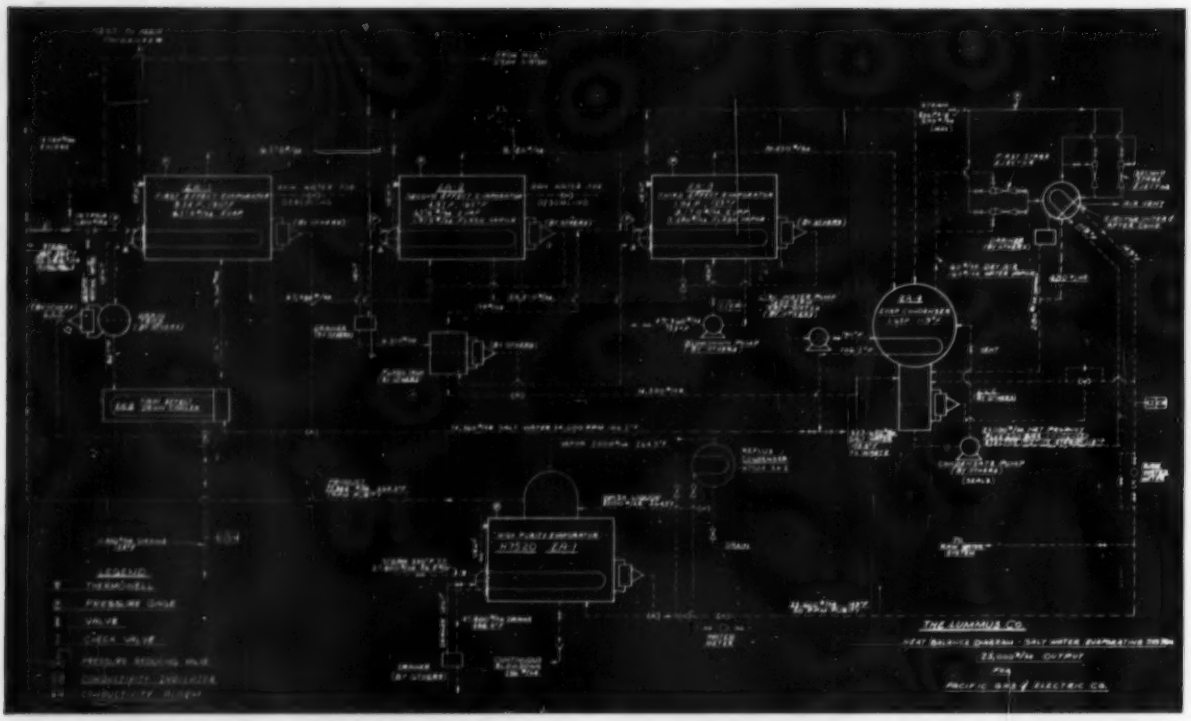
THE Nalco® SYSTEM . . . *Serving Industry through Practical Applied Science*

Nalco WATER TECHS

New reprint of A.S.M.E. Paper No. 52-A-30: *Experimental Studies of Boiler Tube Metal Temperatures: Effect of Heat Transfer Rate and Deposit Thickness*, gives technical data on high-heat-transfer-rate effects (140,000 to 300,000 Btu/sq. ft./hr.) at pressures from 250 to 2500 p.s.i. 16 pages, with tables and diagrams. Author: C. Jacklin, Director, Engineering Research, National Aluminate Corporation.

Your Copy Free Upon Request



THIS EVAPORATOR SYSTEM CONVERTS THE SEA INTO PURE WATER

The Lummus Company, working closely with Pacific Gas & Electric Co. and Bechtel Corporation, has designed and built a system consisting of triple effect evaporators and high purity bubble tray evaporators, one set for each of two boilers.

Each evaporator system will produce 50 gallons per minute of fresh water at design conditions having a vapor purity of less than 1 ppm total dissolved solids, from sea water containing approximately 36,000 ppm dissolved solids.

The ocean water first enters the evaporator condenser and then goes to the first effect drain cooler where it is heated to 150°F. before entering the first effect evaporator shell. From the first effect evaporator shell, the ocean water cascades to the second and third effect evaporator shells at which point its concentration would be one and one-half times that of the entering ocean water.

The vapor from the first and second effect shells is used as the heating medium for the second and third effect shells. Steam from the fourth bleed point of the turbine is used as the heating medium for the high purity evaporator, and part of the vapor from the high purity evaporator is used as the heating medium for the first effect evaporator. The excess vapor produced in the high purity evaporator is bled to the main condenser.

Lummus engineers will be pleased to work with you on your next project.

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THE LUMMUS COMPANY HEAT EXCHANGER DIVISION, 385 MADISON AVE., NEW YORK 17, N. Y.

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STANDARD

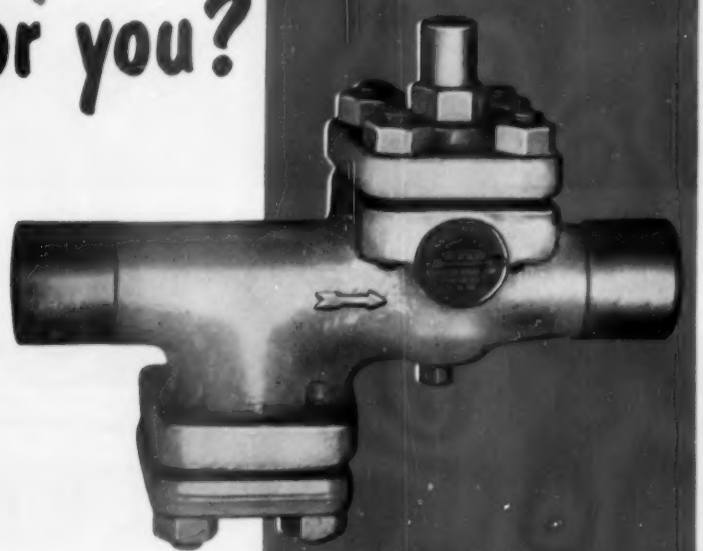
The standard YARWAY Impulse Steam Trap serves all normal trapping requirements. Factory set to operate without adjustment at all pressures from 20 psi to 400 psi (Series 60) and 600 psi (Series 120). For pressures below 20 psi, merely remove split washer.

Numerous advantages like:

small size
quick heating
steady temperatures
stainless steel construction
one moving part
non-freezing
low cost

More than 900,000 used throughout industry.

Write for YARWAY Bulletin T-1740.



HIGH PRESSURE, INTEGRAL STRAINER

YARWAY Integral Strainer High Pressure Impulse Steam Traps operate on some of the highest pressure steam lines in the country. Same operating principle as the standard YARWAY Impulse Trap. Strainer built into trap.

Ample capacity when system is being "warmed up"—yet will handle relatively small amounts of high temperature condensate without losing prime. Six sizes—¼" to 2". Pressures to 1500 psi (flanged ends) or 2500 psi (welding ends).

Write for YARWAY Bulletin T-1740.

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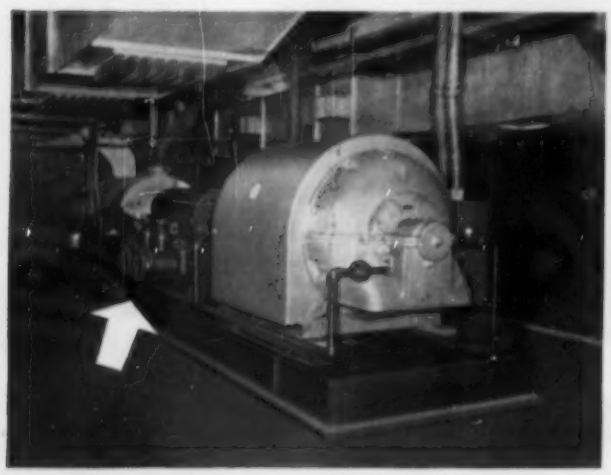
YARWAY

impulse steam traps

YARWAY Impulse Steam Traps and Fine Screen Strainers are stocked and sold by more than 250 convenient local distributors. Write for name of one nearest you.

New England Electric System

Narragansett Electric Company's South Street Steam Station in Providence, R.I. Company is a leading subsidiary of New England Electric System, one of 12 largest electric utility systems in the United States. A multi-million-dollar expansion and modernization program was recently completed at South Street.

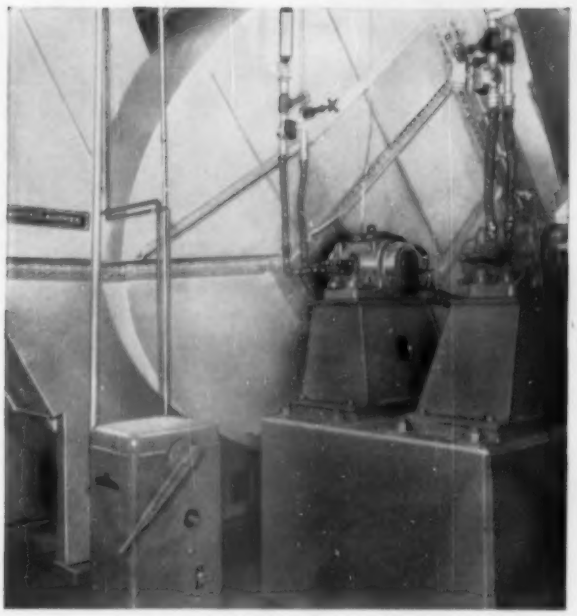


For boiler-feed-pump control, American Blower Type VS, Class 6 Gyrol Fluid Drives are installed at Narragansett's South Street Station. Rating is 2500 hp at 3600 rpm.

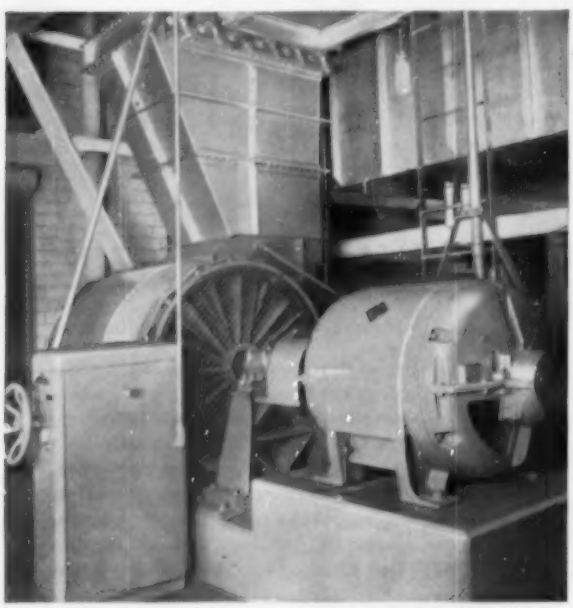
South Street Station is heated by American Blower Type H Steam coils. Capacity: 75,000 cfm at 70°F. Coils are made from tubes of 90-10 cupra nickel.

Serving home and industry: **AMERICAN-STANDARD** •

boosts capacity to 1,000,000 kw



Narragansett uses American Blower Sirocco Induced Draft Fans for air handling. Capacity: 130,000 cfm of gas at 300°F at 22" sp at 875 rpm.



American Blower Sirocco Forced Draft Fan at Narragansett's South Street Station has radial inlet vane control. Capacity: 75,000 cfm of air at 80°F at 18" sp at 875 rpm.

Narragansett Electric Company, a leading subsidiary of the New England Electric System, relies on American Blower products in its expansion program.

In less than fifty years, the New England Electric System has grown from a one-plant operation to the largest utility electric system in New England. A total of 37 plants (including 24 hydro, 12 steam and 1 Diesel operated) supply power to nearly 250 communities in five states. The system now has a rated generating capacity of 1,000,000 kw.

NARRAGANSETT EXPANDS

As part of New England Electric's vast program of expansion and modernization, The Narragansett Electric Company, Providence, R.I., a leading subsidiary, recently completed installation of a new Boiler Topping Unit in its South Street Station, increasing its capacity to 207,000 kilowatts. Steam is taken from the new boilers at 2000 pounds per square inch pressure and 1000°F, and delivered to the Topper. To ensure smooth, adjustable-speed control of the boiler feed pumps, Narragansett chose American Blower Gyrol Fluid Drives—Type VS, Class 6. Narragansett also uses American Blower Forced and Induced Draft Fans, Steam Air Heaters and Ventilating Fans.

CALL ON AMERICAN BLOWER

If you are planning to expand or modernize your facilities, contact your nearest American Blower representative. He can recommend efficient, economical equipment – including Mechanical Draft Fans, Fly Ash Precipitators, Dust Collectors, Heavy Duty Steam Coils and Gyrol Fluid Drives for boiler feed pump and fan control. Call your nearest American Blower Branch Office for full information.

AMERICAN BLOWER CORPORATION, DETROIT 32, MICHIGAN
CANADIAN SIROCCO COMPANY, LTD., WINDSOR, ONTARIO
Division of American Radiator & Standard Sanitary Corporation

AMERICAN BLOWER

AMERICAN BLOWER • CHURCH SEATS & WALL TILE • DETROIT CONTROLS • KEWANEE BOILERS • ROSS EXCHANGERS • SUNBEAM AIR CONDITIONERS

Danskammer Point Steam Station of Central Hudson Gas & Electric Corporation. Consulting Engineers: Burns & Roe, Inc., New York City. Original capacity: 60,000 k.w. Present capacity: 120,000 k.w. Ultimate capacity: 320,000 to 370,000 k.w.

Planning Pays Off at Danskammer Point

In planning the coal-handling system at Danskammer, careful consideration was given to future power needs. By combining the experience of Central Hudson Gas & Electric Corporation...the skill of the consulting engineers, Burns & Roe, Inc....and the know-how of Chain Belt Conveying Engineers, a truly expandable, efficient system was designed.

The coal handling system was carefully planned to serve Unit No. 1, the initial generating unit of 60,000 k.w., and with an extension of the bunker belt conveyor, to serve Unit No. 2 recently placed in operation, providing an additional 60,000 k.w.

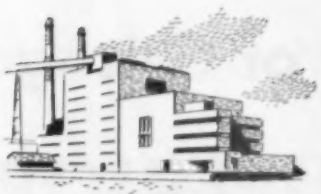
This flexibility of design . . . and efficient operation . . . is typical of the benefits to be gained when you add the specialized skills of Chain Belt Conveying Engineers and top-quality Rex Coal Handling Equipment to your station planning team. When you plan a new station . . . or an expansion of your present one, put the team to work for you. Contact your nearest CHAIN Belt District Office or write CHAIN Belt Company, 4784 W. Greenfield Ave., Milwaukee 1, Wis.

CHAIN BELT COMPANY

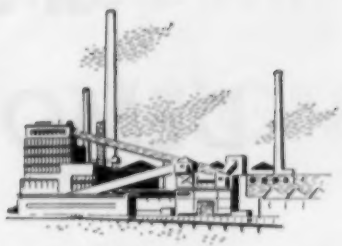
District Sales Offices in all principal cities

6 new units in 6 years

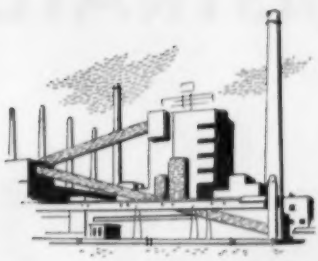
for New England Electric System



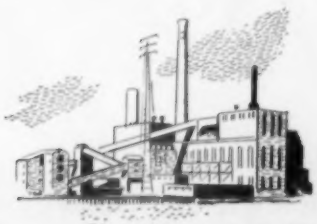
Salem Harbor Station in Salem, Mass.
Two 60,000 kw. units — '51 & '52



Webster St. Station in Worcester, Mass.
30,000 kw. unit — '50



South Street Station in Providence, R. I.
55,000 kw. topping unit — '53



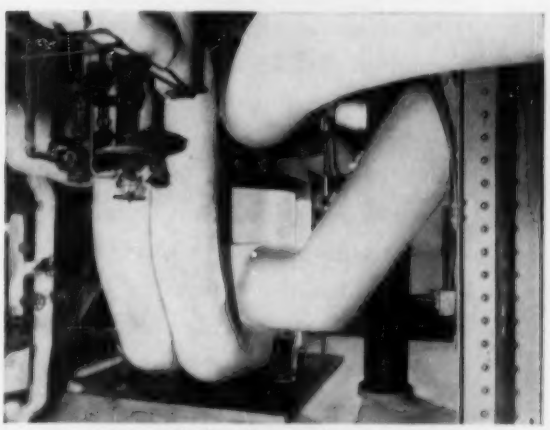
Manchester St. Station in Providence, R. I.
Two 40,000 kw. units — '48 & '49

Proof of the reliability of GRINNELL PREFABRICATED PIPING

Here's a clear-cut case of the value of choosing the right power piping fabricator *from the start!* New England Electric System, when launching its power expansion program, called in Grinnell. Satisfied that Grinnell's facilities rated very high, they okayed Grinnell Prefabricated Piping for the first of a series of new steam-electric generating units. The "proving ground" was to be the unit itself *in service.*

How efficiently that unit performed is written in the record! For starting in 1948, and then each year for 5 consecutive years, Grinnell Prefabricated Piping was employed *exclusively* in constructing 6 new units in the New England Electric System.

This special ability in the fabrication of piping is due to a number of things. Grinnell fabricates in shops under ideal conditions, with modern equipment, by personnel qualified for each class of work. Included in the price (which is determined in advance) are such items of expense as: interpretive engineering, shop sketches and planning, procurement of materials, power services, expendable tools and supplies. There are no charges for waste material or spoilage. All piping is rigidly inspected and tested to comply exactly with customer specifications and applicable codes. Consult Grinnell on *your* next piping installation.



Main steam and reheat lines at reheat intercept valve, Salem Harbor Station.

ATTENTION! *Company Groups and Technical Associations. A 30-minute color sound film showing the quality and economy of Grinnell Shop Fabrication of all classes of piping is available. Write us, giving date desired.*

GRINNELL
WHENEVER PIPING IS INVOLVED

Grinnell Company, Inc., Providence, Rhode Island • Coast-to-Coast Network of Branch Warehouses and Distributors

pipe and tube fittings • welding fittings • engineered pipe hangers and supports • Thermolier unit heaters • valves
Grinnell-Saunders diaphragm valves • pipe • prefabricated piping • plumbing and heating specialties • water works supplies
industrial supplies • Grinnell automatic sprinkler fire protection systems • Amco air conditioning systems

Ingersoll-Rand does it again!

New 110,000 sq. ft. condenser, serving at State Line Station of Chicago

DEMONSTRATES SUPERIOR

The new condenser at Chicago's State Line Station offers another example of the adaptability of Ingersoll-Rand condenser design. It consists of two shells, installed parallel to the shaft of the low-pressure element of the cross-compound steam turbine generator. Each shell has 55,000 sq. ft. condensing surface and forms a unified construction with the turbine's side exhaust which it serves. This forward-looking design for Unit No. 3 eliminates the problems which would have been encountered if vertical condensers had been used in this design.

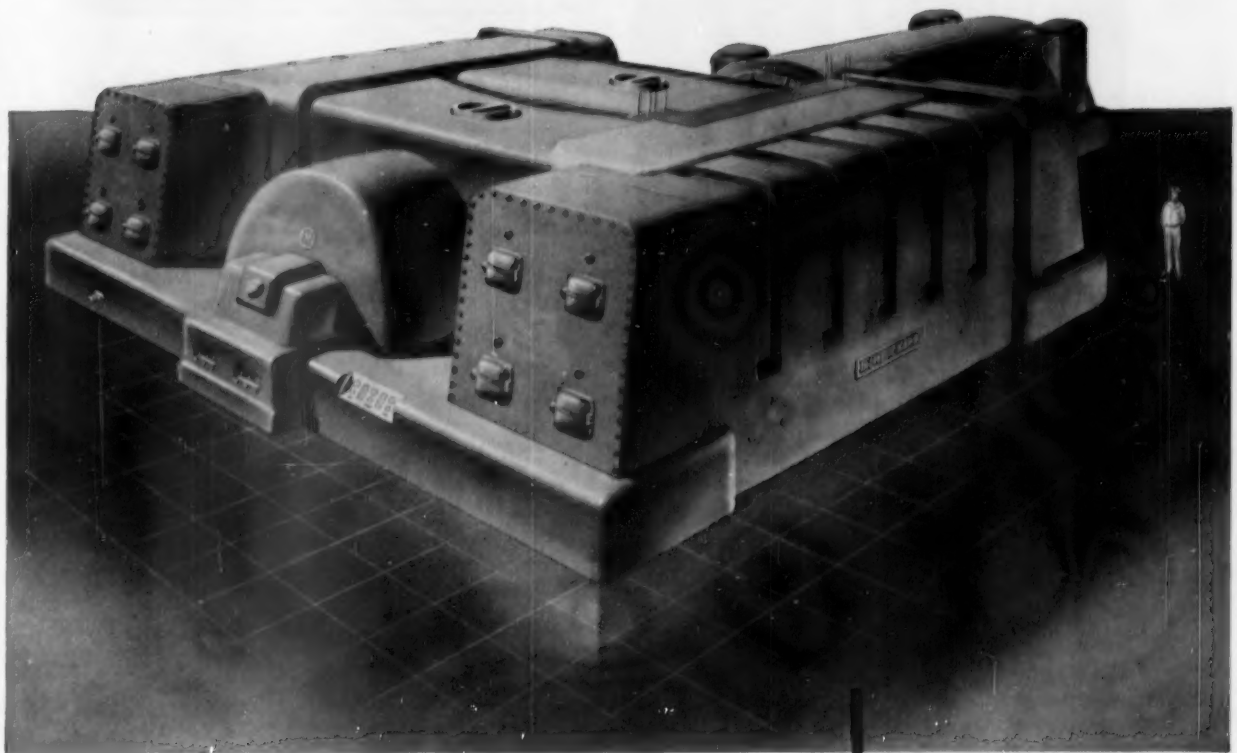
Ingersoll-Rand surface condensers have long set the pace in central station practice. Back in 1920, the basic principle of the I-R surface condenser was introduced as an entirely new concept in design. Ever since, an extensive program of research has been carried on to construct condensers that give top performance in minimum space—under any specified operating conditions. This design for the State Line Station is typical of Ingersoll-Rand's leadership in surface condenser progress.

Ingersoll-Rand horizontal condensate pumps will be used—and three I-R 10-stage Class CHTA "double-case" high-pressure boiler feed pumps will also serve Unit No. 3 at State Line. Ask to have an I-R specialist study your power plant equipment needs—and submit recommendations to meet your particular requirements.

**Wholly owned subsidiary of Commonwealth Edison Company*

PUMPS • COMPRESSORS • GAS AND DIESEL ENGINES • AIR AND ELECTRIC TOOLS •

191,000 kw Unit No. 3
District Electric Generating Corporation*
ADAPTABILITY OF I-R DESIGN



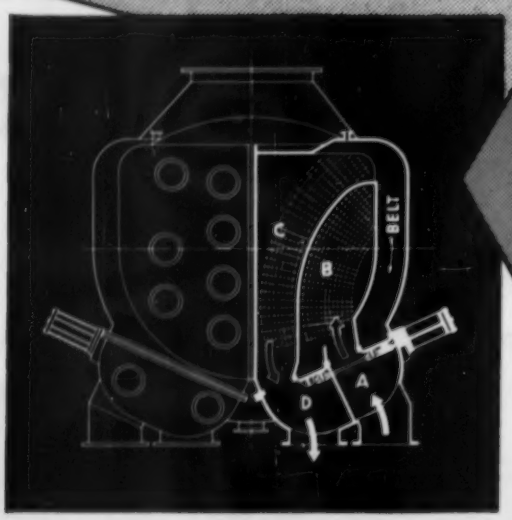
Ingersoll-Rand 110,000 sq. ft. twin-shell surface condenser, to be installed in State Line Station, Chicago District Electric Generating Corporation. Sargent & Lundy, Consulting Engineers.

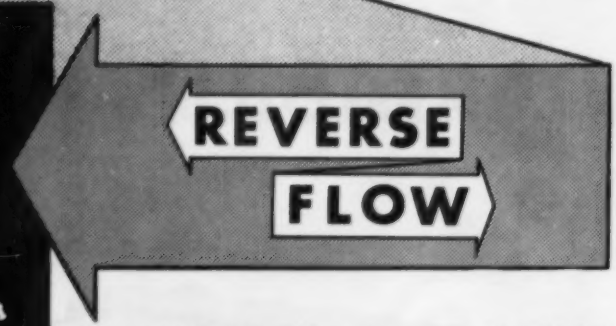
Ingersoll-Rand
11 Broadway, New York 4, N. Y.

4-126

VACUUM EQUIPMENT • ROCK DRILLS • TURBO-BLOWERS

C. H. WHEELER "SELF CLEANING" PATENTED REVERSE FLOW STEAM CONDENSER





Illustrated is the C. H. Wheeler tandem arrangement in which both sluice gates operate on a single stem. In this divided water box condenser, water enters chamber A with left hand port open and flows in through pass B, out through pass C and through left hand port D. To reverse the flow, gates move to left, closing the left hand ports and opening the right hand ports of chambers A & D. Water now flows through bolt, in through C and out through B and right hand port of D. The same method applies, of course, to a non-divided water box design.

No Shutdown — No Vacuum Loss for Tube Cleaning

The C. H. Wheeler Patented Reverse Flow design makes either single or divided water box steam condensers self-cleaning. These condensers are saving power plants countless hours of downtime and reduced load formerly required for manual removal of debris and organic growth from clogged tube sheets.

"Self-Cleaning" is accomplished by a set of sluice gates built integrally into C. H. Wheeler Surface Condensers which may be electrically or hydraulically operated to reverse the flow of cooling water through the tubes. This sudden flushing-in-reverse removes all debris and crustaceous matter and carries it out the discharge while carrying full load on the turbine and without reducing water flow. Also, the quick change in temperature shocks and dislodges marine growth.

Depending on condition of the cooling water, C. H. Wheeler Reverse Flow condensers have gone two years and longer before requiring cleaning. A typical field report tells of regaining a half-inch loss of vacuum (due to fouled tubes and tube sheets) five minutes after reversing the flow of condenser cooling water.

C. H. Wheeler custom - designs Reverse - Flow Condensers to suit any installation, arranging sluice gates and nozzles at top or bottom of water box and at any angle desired. Call a C. H. Wheeler representative to go over your specifications. It will mean years of substantial savings.

(BULLETIN 410 mailed on request)

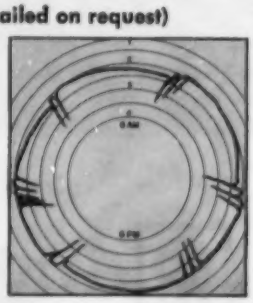
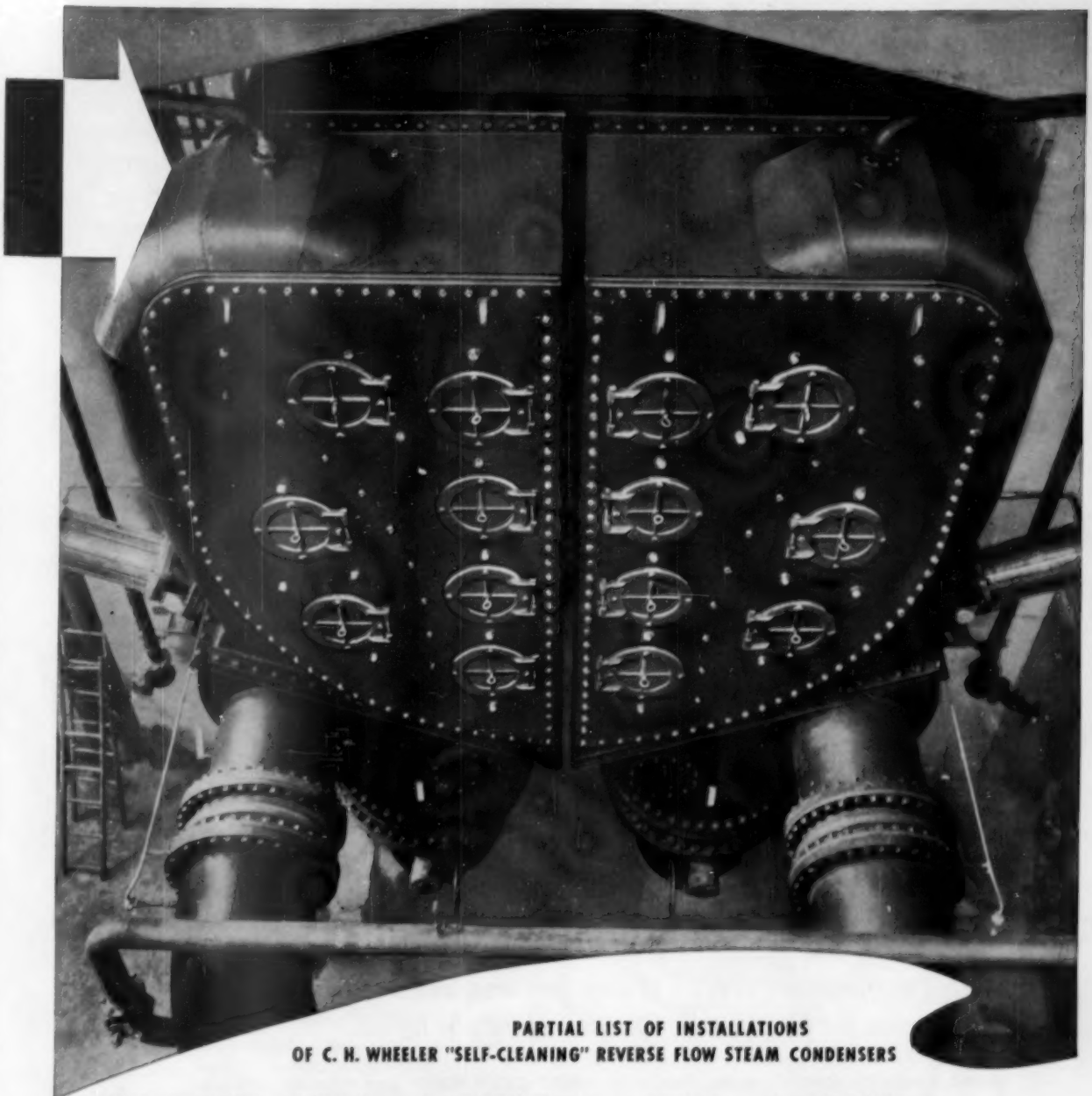


Chart shows typical cycle of vacuum and effect of reverse flow in a C. H. Wheeler Patented Self-Cleaning Reverse Flow Condenser. Note that because of 100% back flushing, the loss of vacuum during the reverse flow cycle is negligible.



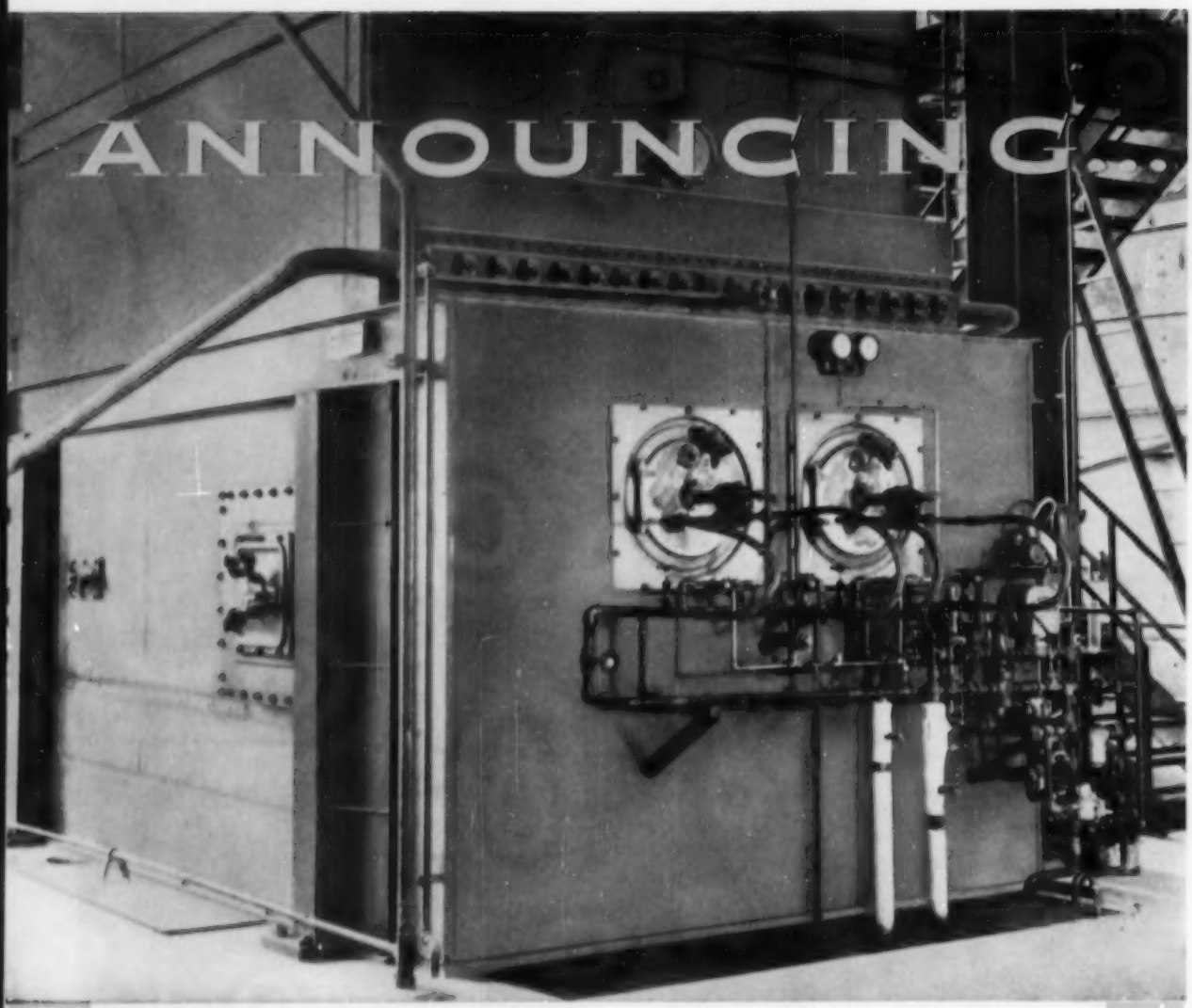
PARTIAL LIST OF INSTALLATIONS
OF C. H. WHEELER "SELF-CLEANING" REVERSE FLOW STEAM CONDENSERS

General Electric Co., Lynn Plant . . 8,900 sq. ft.
General Electric Co., Lynn Plant . . 12,500 sq. ft.
Keystone Steel & Wire, Peoria . . 10,000 sq. ft.
Virginian Railways, W. Va. . . . . 15,000 sq. ft.
City of Wyandotte, Mich. . . . . 12,000 sq. ft.
City of Kansas City, Kansas. . . . 32,500 sq. ft.
New Bedford Gas & Edison Light,
New Bedford, Mass. . . . 16,500 sq. ft.
New Bedford Gas & Edison Light . 25,000 sq. ft.
Connecticut Light & Power Co.,
Montville Station . . . . . 24,000 sq. ft.
Connecticut Light & Power Co. . . 24,000 sq. ft.
Connecticut Light & Power Co.
Devon Station . . . . . 50,000 sq. ft.
Georgia Power Co., Atkinson Station, 47,000 sq. ft.
Alabama Power Co , Units 1 & 2
Gadsden Station . . . . . 47,000 sq. ft.
City of Holland, Michigan . . . . . 13,000 sq. ft.
South Carolina Electric & Gas,
Unit #1 Urquhart Station . 45,000 sq. ft.
South Carolina Electric & Gas,
Unit #2 Urquhart Station . 45,000 sq. ft.
Connecticut Light & Power,
Montville Station . . . . . 55,000 sq. ft.
Monongahela Power Company,
Albright #3 . . . . . 65,000 sq. ft.
Georgia Power Company,
Hammond Station, Units 1-2-3, 74,000 sq. ft.
City of Jacksonville, Fla.,
Southside Station . . . . . 40,000 sq. ft.
Tallyrand Station . . . . . 40,000 sq. ft.

C. H. WHEELER *of Philadelphia*

C. H. WHEELER MANUFACTURING CO., 19th & LEHIGH, PHILADELPHIA 32, PENNA.

Steam Condensers • Centrifugal, Axial and Mixed Flow Pumps • Steam Jet Ejectors • Vacuum Refrigeration
High Vacuum Process Equipment • Micro Particle Reduction Mills • Marine Condensers and Ejectors • Deck Machinery



High-Temperature (H-T) Water has important advantages over Steam for Heating or Process. Here's Why . . .

HIGHER AVAILABLE HEATS are on tap. Many more Btu's are in a cubic foot of H-T water than in a cubic foot of steam at the same pressure. The greater storage volume, full of a higher Btu-carrying fluid, gives a heat reservoir from 40 to 100 times that of an equivalent steam system.

UNIFORM TEMPERATURE CONDITIONS prevail at all loads because water is circulated throughout the system under positive controlled pressure. In process plants, you can isolate special equipment for very fine temperature control, to produce a better product.

CLOSE CONTROL OF TEMPERATURE can be maintained either at the boiler or at individual pieces of equipment. Since temperature in the H-T water system need not be a direct function of system pressure, moderate adjustment does not affect boiler operation.

SIMPLIFIED BOILER OPERATION is a result of the system's inherent heat reservoir. This permits use of automatic controls of proved reliability.

HEAT LOSS IS MINOR since H-T water systems are usually fully closed, constantly circulating water back to the boiler with no condensate losses. Thus, heat not used in process or heating returns to the boiler. This represents a fuel saving of 10-20% . . . one that's more apparent the longer you operate the boiler.

NO ELABORATE FEEDWATER TREATMENT is needed. Since most H-T water systems are closed, full of water and free from air spaces, makeup requirements are a few gallons a day at most. Furthermore, there can be no active corrosion resulting from air-contact of wetted surfaces. These add up to substantially lower operating and maintenance expenses.

NO STEAM TRAPS which means the elimination of trap problems, maintenance costs and heat losses.

NO PIPING GRADIENTS are required, because there is no condensate drainage to consider. What's more, since the H-T water is under positive pressure, there is maximum flexibility in the arrangement of heating circuits.

The C-E La Mont Controlled Circulation Hot Water Boiler

for large heating and process applications

Combustion's high-temperature (H-T) water boiler is especially designed to utilize the inherent advantages of hot water over steam (see opposite page) for large central heating installations and for many process applications. Units are available in sizes from 10,000,000 Btu per hour up, for any fuel, with pressures up to 300 psi and water temperatures to about 425 F. The chief advantages of the C-E La MONT *Controlled Circulation* Hot Water Boiler are:

Complete control — System control over the H-T water movement is extended to the boiler at all heat rates, since the water is under positive, controlled pressure.

Low pressure loss — Because of the low pressure loss inherent in the design, the system circulating pumps can be used to provide circulation through the boiler.

Pressurized operation — Used with oil or gas fired boilers, pressurized operation permits a simple stack arrangement and eliminates the need for induced draft fans.

Single-pass design — Absence of baffles not only assures low draft loss but also a cleaner boiler since there are no dead areas where deposits are likely to accumulate.

High furnace heat rates — The close spacing of furnace wall tubes offers greater wall protection, permits high heat rates in the furnace with low maintenance.

More efficient heat transfer — Since the water is positively circulated through the heating circuits, these circuits may be proportioned and arranged for maximum efficiency.

Lighter boiler weight — Less surface is needed because heating surfaces are more efficient. With closely spaced wall tubes, setting thickness is reduced.

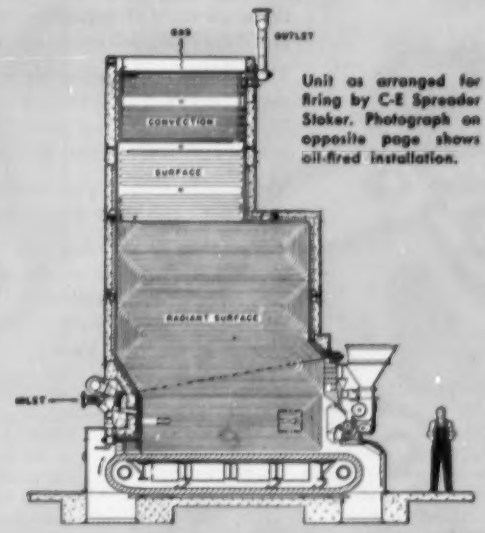
Any fuel — Boilers can be arranged for oil or gas burners, or spreader stokers. Special designs using other types of firing or waste heat are also available.

Other design features — All boiler tubes are completely drainable and ventable—small number of headers all accessible from outside of casing — completely steel-enclosed setting.

If you have a heating or process job that's suitable for high-temperature water, it will pay you to look into a C-E La Mont installation. As compared to steam, it will give you a simpler and less expensive distribution system and lower fuel and maintenance costs, plus the specific advantages described at left. Write for further information.

TYPICAL APPLICATIONS OF H-T WATER

Space Heating	Heating Platens
Ovens	Hot Tables
Tanks	Snow Melting Coils
Kettles	Cafeteria and
Calendar Rolls	Kitchen Apparatus



Unit as arranged for firing by C-E Spreader Stoker. Photograph on opposite page shows oil-fired installation.

B-806C

COMBUSTION ENGINEERING

Combustion Engineering Building • 200 Madison Avenue, New York 16, N. Y.

BOILERS, FUEL BURNING & RELATED EQUIPMENT; PULVERIZERS, AIR SEPARATORS & FLASH DRYING SYSTEMS; PRESSURE VESSELS; AUTOMATIC WATER HEATERS; SOIL PIPE

A Red Hot Proposition

Buell offers you a unique opportunity to eliminate nuisance dust problems . . . without risking a single cent!

Many of America's Leading Corporations have already taken advantage of this 'red hot proposition'. Why don't you?

Just call in a Buell Engineer and put your problem in his hands. First, he will analyze dust samples from your stack, then make a thorough study of operating conditions. Finally, he will recommend the best Buell equipment to handle *your* job.

There are many variables that make each job different. One may require the fabulously successful Buell 'SF' Electric Precipitator. The simple design and proved efficiency of the Buell Cyclone may suffice for another. A third may require a combination.

The *right* equipment plus over twenty years of skill and experience enables Buell to handle *any* dust collection problem.

Take advantage of this 'red hot proposition' now. Get the complete facts about all *three* Buell systems described in our brochure—The Collection and Recovery of Industrial Dusts. Write Dept. 70-C, Buell Engineering Company, 70 Pine Street, New York 5, N. Y.

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MECHANICAL ELECTRICAL

20 Years of Engineered Efficiency in

DUST COLLECTION SYSTEMS

MODERN METHODS of Coal Handling

COAL IS RECLAIMED AS NEEDED from the storage pile of a Michigan industrial plant by this Allis-Chalmers 109 drawbar hp HD-15 Tractor with Gar Wood straight blade and wings. It moves about 9 tons of coal at a time. Unit also stores coal, which is brought in by rail. Tractor handling of coal is flexible, can either supplement existing facilities or take over complete job. Permits adding storage areas without installing costly conveyors, tracks, etc. — or abandoning them without leaving money tied up in idle equipment.

14 TONS OF COAL AT A TIME is stockpiled or reclaimed at an Eastern utility by this HD-20 Tractor with special Baker coal blade. Blade design takes advantage of tractor's big 175 net engine hp, permits moving up to 15 percent more coal than with regular blade. Repeated trips of 25-ton unit over stockpile compacts coal, helps prevent spontaneous combustion.

COKE IS STOCKPILED AT A STEEL MILL leveled and compacted by this Allis-Chalmers 72 drawbar hp HD-9 Tractor — then is reclaimed as needed for the plant. Wintertime operation no longer is hindered by freezing of coke surface as it was with system previously used.

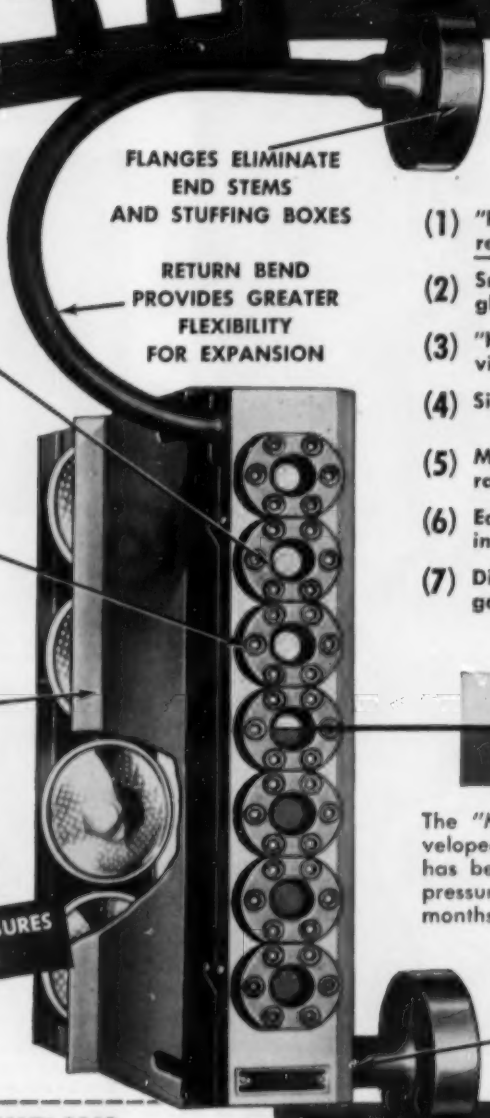
VERSATILE HD-9G WITH 3¾-YD. (2.8-TON) BUCKET builds storage pile of coal brought to Midwest industrial plant by truck. These coal-handling buckets are available for all four Allis-Chalmers tractors, from 2-yd capacity on the HD-5G to 7-yd on the HD-20G. Blades and other attachments are interchangeable with buckets to widen the usefulness of Tractor Shovels.

Find out more about how Allis-Chalmers equipment can improve your coal handling at lower cost. See your Allis-Chalmers dealer for a demonstration right at your plant, or ask to see the color film showing coal-handling equipment at work. Also, send for free booklet, "Economic Coal Storage."

ALLIS-CHALMERS

TRACTOR DIVISION • MILWAUKEE 1, U. S. A.

NEW DIAMOND "MULTI-PORT"® Bi-Color Gauge



SMALL ROUND INDIVIDUAL PIECES OF MICA AND GLASS

PORT PARTS REPLACED WITHOUT REMOVING GAUGE FROM BOILER

"HI-LITE" ILLUMINATOR

FOR BOTH NEW AND OLD BOILERS

FOR BOILER PRESSURES TO 3000 PSI

FLANGES ELIMINATE END STEMS AND STUFFING BOXES

RETURN BEND PROVIDES GREATER FLEXIBILITY FOR EXPANSION

STEAM SHOWS RED

WATER SHOWS GREEN

WELDED CONSTRUCTION ASSURES PERMANENT TIGHTNESS

6962

"MULTI-PORT" Advantages:

(1) "Bi-Color" principle shows steam red and water green

(2) Small round ports instead of long glass strips

(3) "Hi-Lite" Illuminator for improved visibility

(4) Simplified high-pressure construction

(5) Maximum thermal stability for rapid starting

(6) Easy, inexpensive maintenance . . . in place

(7) Direct reading . . . basic reference gauge

The "Multi-Port" gauge has been developed over a four-year period and has been in continuous successful high pressure operation for more than 18 months in several leading central station plants. For additional information, write for new Bulletin 1174 . . . use the coupon below.

SEND TODAY

DIAMOND POWER SPECIALTY CORP. V
LANCASTER, OHIO

Please send me without obligation a copy of new Bulletin No. 1174 explaining the advantages of the Diamond "MULTI-PORT" Bi-Color Gauge.

NAME_____

COMPANY_____

ADDRESS_____

DIAMOND POWER SPECIALTY CORP.
LANCASTER, OHIO
Diamond Specialty Limited—Windsor, Ontario

General View of Meredosia Power Station
Central Illinois Public Service Co.
Sargent and Lundy
Consulting Engineers

Bartlett-Snow coal handling at Meredosia

● The illustration above shows the first 100,000 KW unit of a plant which is to be extended into a 200,000 KW station. All coal handling equipment including the receiving and reclaiming hoppers and grillage, duplex feeder, conveyors, galleries, breaker screen and all supporting structures were fabricated in our shops, and installed by us, to Sargent and Lundy's specifications. For maximum efficiency and fixed unit responsibility, let the Bartlett-Snow coal handling engineers, with their long experience and complete facilities, work with you on your next job.

Belt Conveyor in Tunnel
Handling Coal from Track Hopper

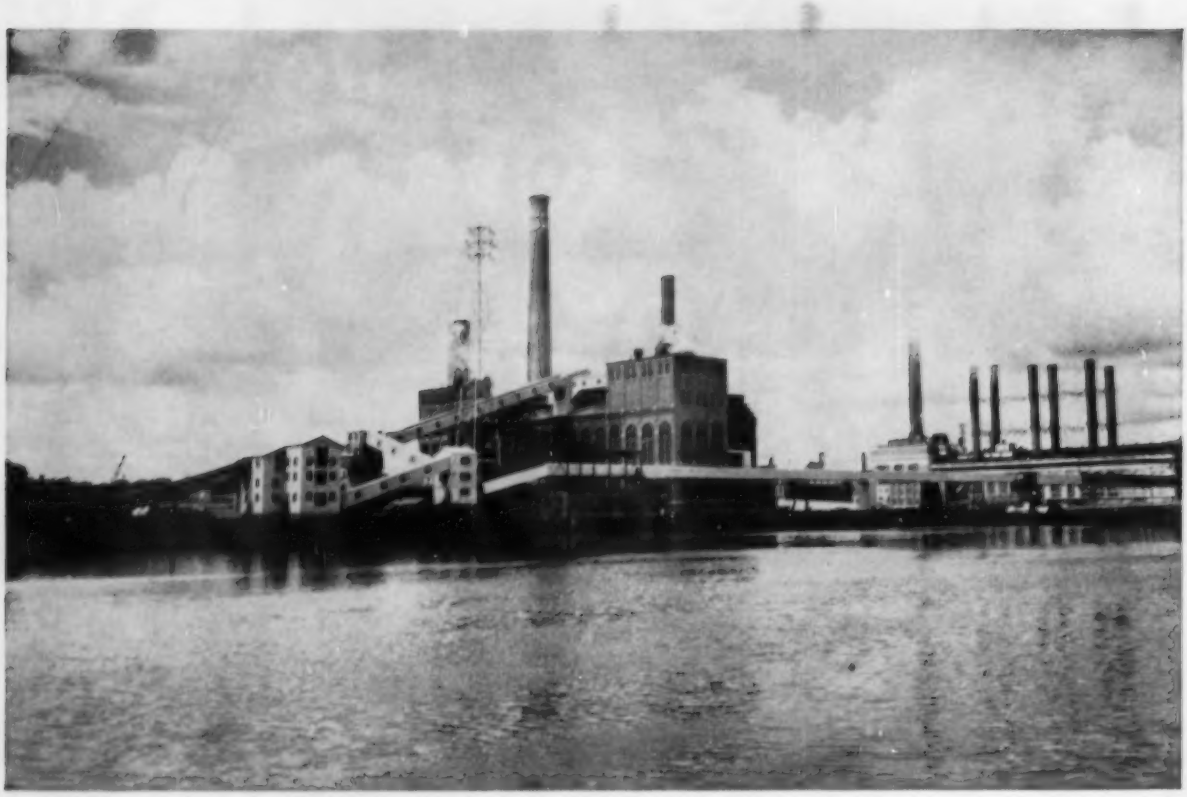
Drive for Collector Belt Under Breaker
the Refuse Belt and Automatic Sampler

DESIGNERS ENGINEERS

BARTLETT-SNOW
CLEVELAND 5, OHIO

FABRICATORS ERECTORS

"Builders of Equipment for People You Know"



When coal is carried to Narragansett, U. S. Rubber conveyor belts take over

This "U.S." belt carries coal at a rate of 1000 tons per hour at a speed of 615 feet per minute, to a crushing station.

When coal arrives at the docks of the Narragansett Electric Company, conveyor belts get to work and haul the coal to crushers, then to storage, and finally to the boilers which motivate the generators. Eight different belts are used, all made by United States Rubber Company. They do their job so steadily, economically and dependably that officials of the electric company have ordered additional "U.S." belting for further expansion.

"U.S." belting technicians are constantly coming up with new developments that pay off at a dollars-and-cents level for you. Familiarize yourself with the advantages of "U.S." Three-Way Engineering. Get in touch with any of the 27 "U.S." District Sales Offices, each staffed with engineers. Or write to address below.

"U.S." Research perfects it.
"U.S." Production builds it.
U.S. Industry depends on it.

US RUBBER

UNITED STATES RUBBER COMPANY

MECHANICAL GOODS DIVISION · ROCKEFELLER CENTER, NEW YORK 20, N. Y.

Hose • Belting • Expansion Joints • Rubber-to-metal Products • Oil Field Specialties • Plastic Pipe and Fittings • Grinding Wheels • Packings • Tapes Molded and Extruded Rubber and Plastic Products • Protective Linings and Coatings • Conductive Rubber • Adhesives • Roll Coverings • Mats and Matting

why soot is no problem... with the Ljungstrom® Air Preheater

Soot is no problem with the Ljungstrom. Clinging soot or slag is loosened by normal expansion and contraction of the preheater . . . and most of it is blown away by the high-velocity gas streams. What remains is removed by superheated steam or compressed air, fired from oscillating soot blowers, while the Ljungstroms are in operation.

What's more, moderate deposits on the Ljungstrom heating surface have no effect on preheating. For, with the Ljungstrom, heat need not pass through a film-coated wall — but is simply absorbed by a heating surface and *released from the same surface.*

Get all the details on why the Ljungstrom is easier to clean and maintain . . . maintains higher boiler efficiencies. They're in the new, 38-page reference manual, "Ljungstrom Air Preheaters." Write for your free copy, today!

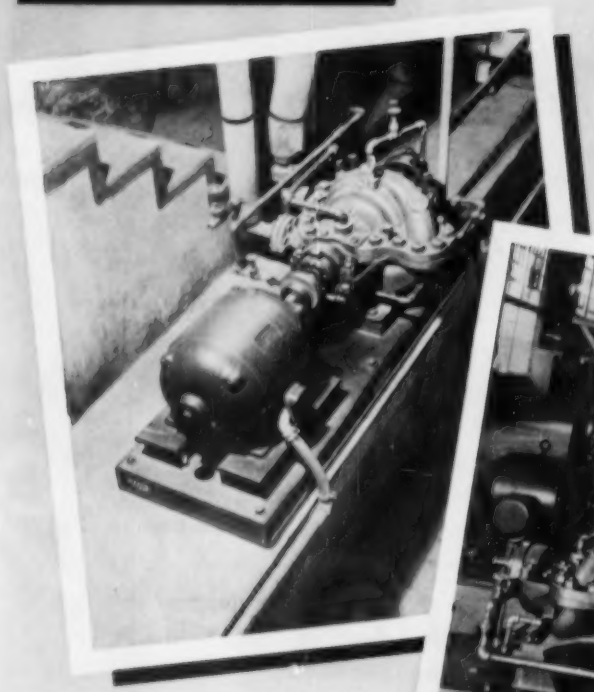
Advantages of the Ljungstrom Air Preheater

- Size for size, recovers more heat than any other type.
- Reduces fuel consumption. Permits use of lower-grade fuels. Increases boiler output and reliability.
- Eliminates cold spots . . . keeps corrosion to a minimum.
- Easier, faster to clean and maintain.
- Requires far less supporting steel and is quickly erected.

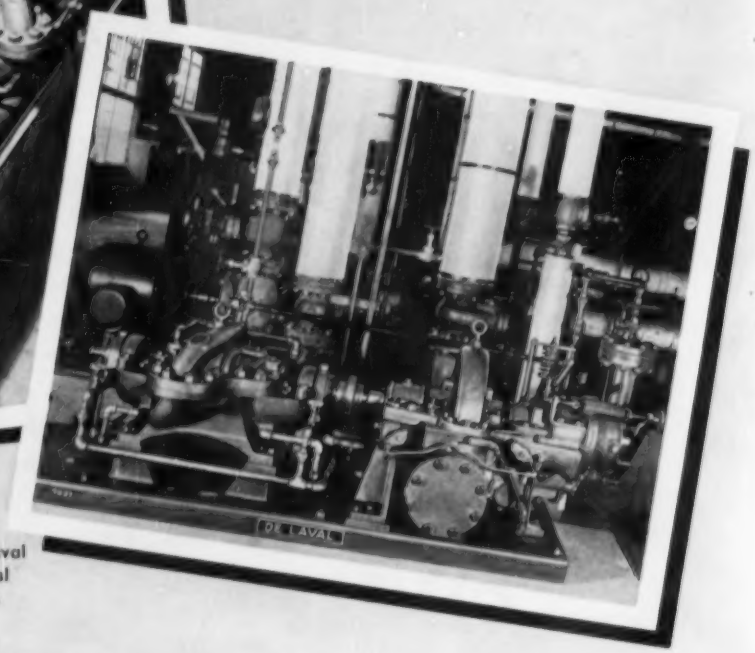
The Air Preheater Corporation 60 East 42nd Street, New York 17, N. Y.

DE LAVAL
TWO-STAGE HORIZONTAL PUMPS

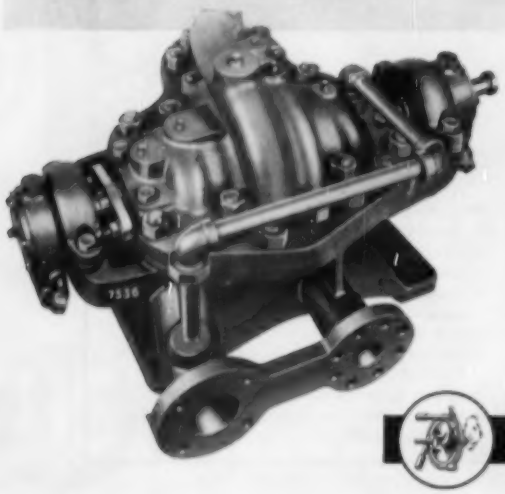
for dependable boiler feed service in institutions . . . industrial plants



Institutions can't afford shutdowns. In this hospital installation a motor-driven 21S boiler feed pump provides year-in, year-out dependability. It delivers 70 gpm of 240° water at 420 ft. head.



Industrial plants, too, choose reliable De Laval pumps for boiler feed service. This De Laval unit, driven by a De Laval turbine, delivers 160 gpm of 215° water at 520 ft. head.



There are good reasons why De Laval 21S-2KS two-stage horizontal split case pumps give long, economical boiler feed service. They are designed with • back-to-back impellers for balanced hydraulic thrust • easily replaceable threaded impeller wearing rings • long life labyrinth case rings • ring oiled ball bearings — plus ten other important design features.

These De Laval pumps are available in sizes from 2" to 8" discharge, for capacities from 75 to 3,000 gpm and heads to 750 ft.

Write for Bulletin 1501 giving complete data.

DE LAVAL *Boiler Feed Pumps*

DE LAVAL STEAM TURBINE COMPANY
886 Nottingham Way, Trenton 2, New Jersey

DL 574

This ring has been in service six months...

BUT WHERE'S THE SLAG?

The answer is simple. There isn't any.

That's because the burner ring, like two others in this central station, is made of CARBOFRAX® silicon carbide refractory. After six months of operation, the surface of the CARBOFRAX segments is practically as smooth as the day they were installed. As a matter of fact, this utility is so conscious of the problem of slag accumulation that they have lined the boiler wall between the burner rings with CARBOFRAX brick, too.

Silicon carbide won't soften, no matter how high the temperature inside the boiler goes. Slag can't fuse to its hard, dense surface . . . can't build up and deflect the flame . . . can't drop off in heavy chunks to harm the tubes below. And naturally, without accumulated slag to be barred off, there's no risk of damaging the refractory during routine maintenance.

CARBOFRAX burner rings resist abrasion by coal, as well as heat shock and flame erosion — even an out-of-line burner has little effect on them. Like to find out more about how these remarkable refractories can increase *your* firing efficiency? . . . Write today for our free booklet, "Super Refractories." Address Dept. E35, Refractories Division, The Carborundum Company, Perth Amboy, N. J.

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OLD BEN COAL

Old Ben Coal is prized by "chiefs" of many Midwestern steam plants as a prime producer of low cost steam. And there are sound reasons for its high rating. The high quality, ideal steaming characteristics, and trouble-free storage ability of Franklin County coal are legendary with these men who know coal best!

Consider, too, Old Ben's substantial productive capacity ...enormous reserve acreage...refineries of latest design... nearness to market! *A consultation with an Old Ben engineer on your energy requirements might well be indicated.*

WHEREVER HEAT, LIGHT OR POWER IS NEEDED

ACCESSIBLE TO RAIL-WATER TRANSPORTATION

OLD BEN COAL CORPORATION

CHICAGO 4, ILLINOIS

HEATER EFFICIENCY RESTORED

Chemical cleaning by Dowell removed scale from four feed-water heaters in less than one day.

An iron oxide and silica scale had greatly reduced the efficiency of four feed-water heaters in a power plant. The operator asked Dowell to clean the heaters in the shortest possible time.

Dowell engineers made connections to permit circulation of solvents through the complex tubing of all four units at one time. The heaters were cleaned in a matter of hours. Terminal Temperature Differences, checked before and after cleaning, were greatly reduced.

TERMINAL DIFFERENCE		
	Before Cleaning	After Cleaning
#1 Heater	16°F.	9½°F.
#2 Heater	22°F.	5°F.
#3 Heater	22°F.	7°F.
#4 Heater	26°F.	2°F.

Because chemical solvents are introduced through regular connections, dismantling and downtime are held to a minimum. Moreover, solvents will go wherever steam and water flow—cleaning all curves, angles and irregular surfaces down to the smallest tubing. Many pieces of equipment are cleaned while in operation.

Keep your plant operating at its best. Call your nearest Dowell office for full information on how chemical cleaning can serve you. Or write Dowell Incorporated, Tulsa 1, Oklahoma, Department C-25.

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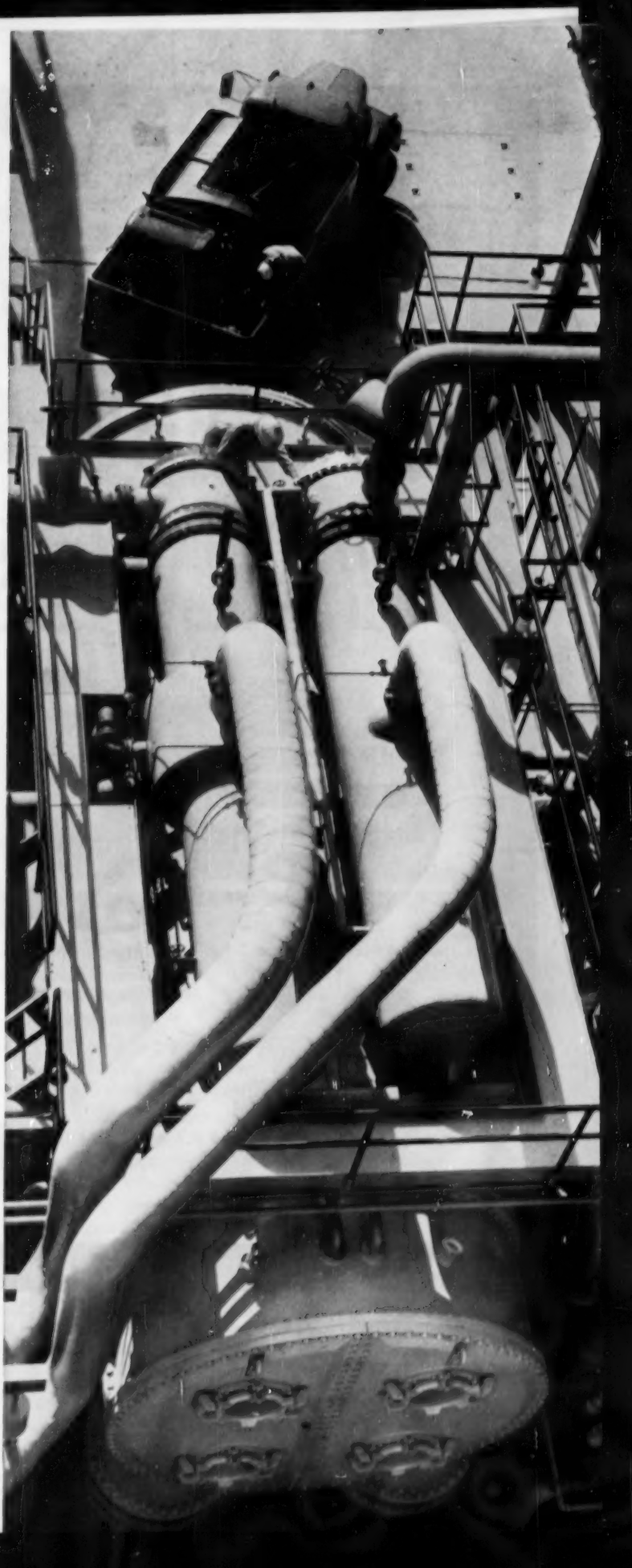

POWELL VALVES . . . THE COMPLETE QUALITY LINE . . . POWELL VALVES

. . . THE COMPLETE QUALITY LINE . . . POWELL VALVES . . . THE COMPLETE QUALITY LINE . . .

POWELL STEEL VALVES

FIG. 11323—1500-Pound Motor Operated Steel Pressure Seal Gate Valve

FIG. 3003 WE—Steel Gate Valve For 300 Pounds W.S.P.

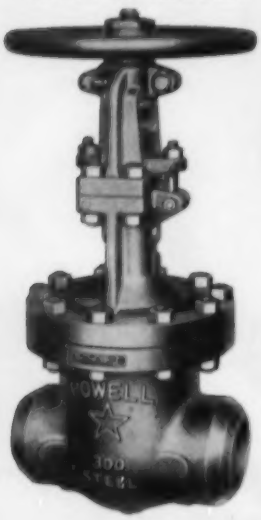

FIG. 11365—Steel Pressure Seal Horizontal Lift Check Valve For 1500 Pounds W.S.P.

FIG. 1314-A—1500-Pound Integral Bonnet Steel "Y" Valve

POWELL VALVES . . . THE COMPLETE QUALITY LINE . . . POWELL VALVES

Wherever flow requires dependable control, there's the place for Powell Valves. Powell can supply just the valve you need, for Powell probably makes more kinds of valves and has solved more valve problems than any other organization in the world.

Shown above are just a few Powell Steel Valves. Investigate their many outstanding features . . . *and the complete line* of quality valves famous for dependable service.

Consult your Powell Valve distributor. If none is near you, we'll be pleased to tell you about our complete line, and help solve any flow control problem you may have. Write . . .

The Wm. Powell Company, Cincinnati 22, Ohio . . . . . 109th year

Now watch combustion conditions every minute of the day

. . . with RCA Industrial TV

With RCA's new water-cooled window—you maintain continuous observation of flame conditions and ignition—*at the control panel*—24 hours a day. High-detail picture eliminates the need for periodic observation of furnace and checking burner operation.

Water-cooled window can be installed at top of furnace to observe tangential firing—in side of furnace to observe direct firing. High-capacity blower and pump unit can serve two windows.

HERE'S THE ANSWER to continuous, low-maintenance, fail-safe observation of furnace conditions . . . high-detail RCA Industrial TV (ITV-5A) and the new RCA water-cooled window.

By using a high-efficiency circulating system, RCA has reduced lens temperatures at the camera below 120° F—for stable, dependable camera operation.

The RCA Industrial TV water-cooled window is a reliable tool for use by your operators for continuous remote observation of combustion conditions. RCA now offers this new revolutionary equipment as a complete, engineered package to power plants—plus installation and maintenance service.

FOR INFORMATION on RCA Industrial TV (Type ITV-5A), write Radio Corporation of America, Dept. 0-187, Building 15-1, Camden, New Jersey.

INDUSTRIAL PRODUCTS
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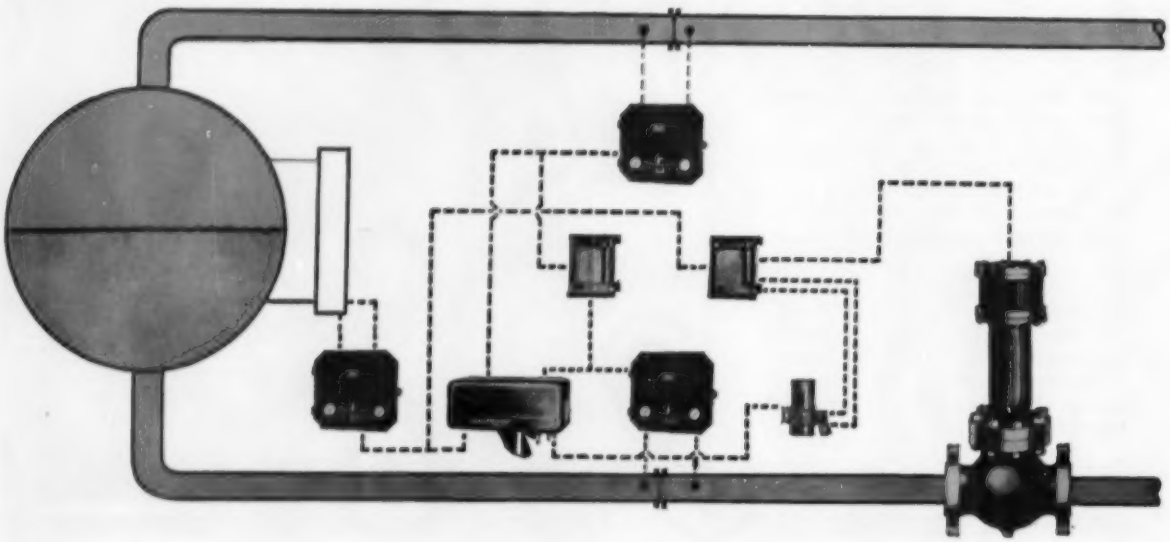
. . . **WITH** **RECORDING INSTRUMENTS**



From the oldest comes the newest in three-influence feed water control—Copes Type 3-L with Taylor instruments. A minimum of instruments are required due to simplicity. Miniature recorders are indicated above. Standard size recorders may also be used to supply as many as four records on one chart. Each component of the Type 3-L system is selected for its accuracy and high quality. Each installation is backed by nationwide service, whenever or wherever required, for its entire life.

Copes three-influence control may also be actuated mechanically or electrically

COPES

First to develop continuous

BOILER FEED

TYPE 3-L SYSTEM

3-influence controls

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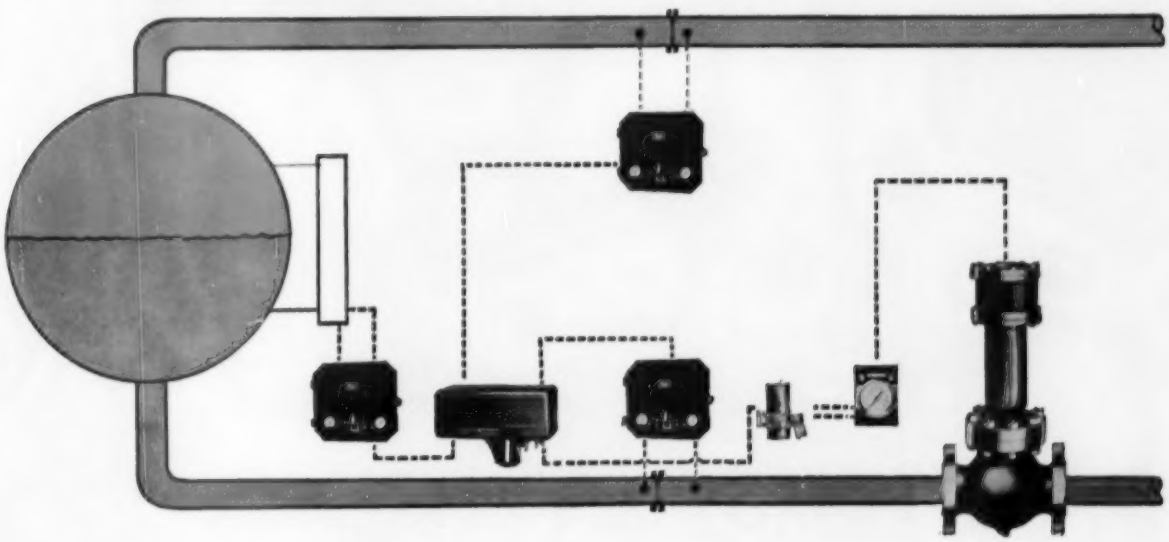

To further simplify a 3-L system, recorders may be omitted. The schematic shown above is the simplest instrument-type Copes three-influence feed water control system that is available. Ask for Bulletin 103-A which describes the combinations available in Type 3-L feed regulation.

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WATER REGULATION

Let's face it

...there's more to a bid than price. Some bids are full of gimmicks; some are true. When you receive bids for your specialized piping requirements there's much to consider beyond the price. Your initial saving in accepting the low, low bid that's frequently full of hidden extras is quickly lost in added costs of expediting, in delayed construction schedules, and in correcting faulty fabrication and welding.

When you buy from a financially sound fabricator backed by world-wide reputation and sixty-one years of piping experience, you are guaranteed the successful operation of every piece of pipe that is shipped to you. Avoid the low, gimmick-type bid. Count on Shaw for careful, accurate bidding - dependable fabrication and installation. Buy from Shaw. It pays - all ways.

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Editorials

How to Interest Youth in Mathematics

In the June 1954 issue of COMBUSTION we ran as our lead editorial the very same title as we have chosen for this month. That earlier editorial evoked considerable interest and because of this interest we are pleased to comment on a new approach recently called to our attention on the problem of how to interest youth in mathematics.

This approach now under field trial in a dozen classes in five schools—University High School, Urbana, Ill., Barrington, Blue Island and Pekin, Ill., high schools and Dearborn, Mich., high school—is a joint development of three University of Illinois units, the Colleges of Education, Engineering, and the Liberal Arts and Sciences math department. It grew from a committee formed in 1951 to help high schools meet increasing math requirements of engineering colleges. Briefly, it has been designed to interest more high school students in math, to teach them more of the important ideas of math and to give them a broad understanding of principles rather than just manipulative skills. The emphasis is on understanding *why* and not on memorizing *how*.

To achieve this laudable aim a distinct departure is made with tradition. Words, for example, are thought up for numbers. Students learn that addition or multiplication is just as possible with these new terms as with those more conventional. From this departure they learn that the concept is important, not what we call it. Few high school students, we are told, ever understood this before—the idea usually is presented in college, and peculiarly, also first grade.

This is the sort of *why* the new program presents. It emphasizes understanding rather than the isolated facts of traditional courses. It shows the relation of algebra, geometry and the like and this permits teaching more math in the same amount of class time.

For the two out of three students who never go beyond one year of high school math, the program presents a lot of useful information, far more useful than the traditional first-year algebra course, and at the same time is a better foundation for those studying more than one year which, after all, is the programs objective.

It acquaints a student with math, algebra, geometry, and trigonometry, making it possible for him to choose more intelligently whether he wishes to go into a life work, such as engineering, in which math is important.

He learns, too, that math is not a dead subject about which everything is known. The program is said to be stimulating to the talented student, at the same time highly valuable to the less talented because of its emphasis on understanding.

The new teaching program was started two years ago. In 1956 when the third year is completed, students will be tested against others who have had four years of conventional high school mathematics.

Integrating the teaching of high school math to do away with the artificial subject barriers has been talked about for years. To our knowledge this is the first time a real attempt has been made to do something quite different from the traditional routine. We fervently hope the comparison tests of 1956 will confirm the convictions of the program's founders. Certainly the results will be viewed with great interest by educators and industry alike and merits early study if successful.

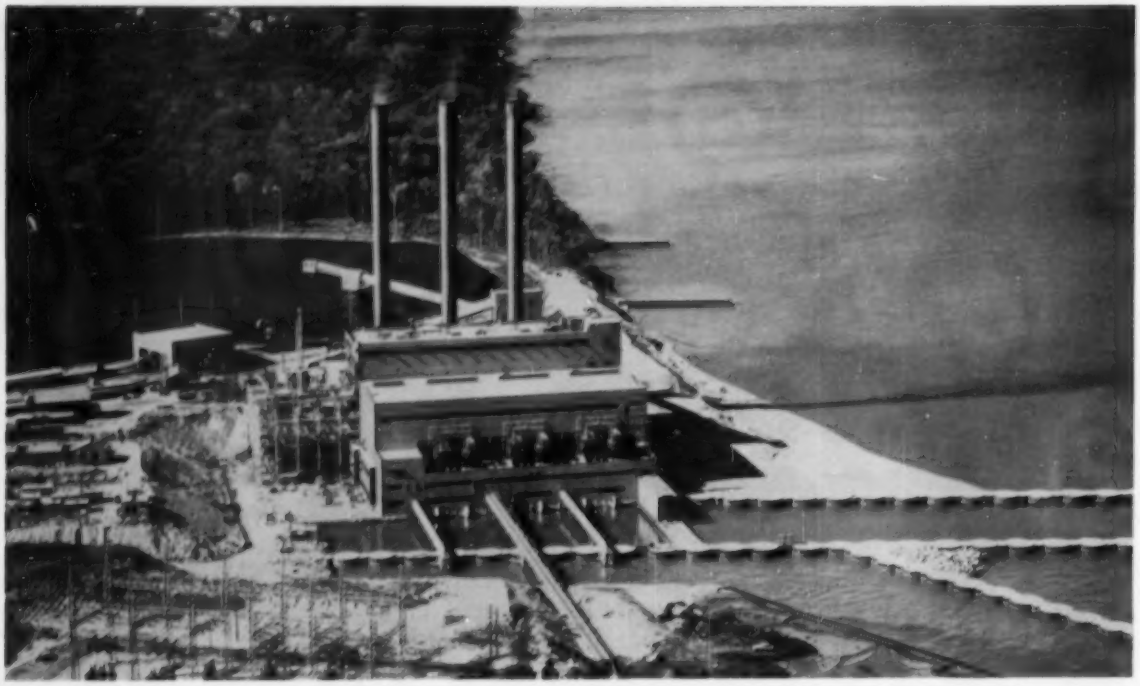


Fig. 1—Aerial view of the new Eastlake Plant of Cleveland Electric Illuminating Co. pictures the outdoor coal storage pile and some of the coal handling equipment, upper left, the steel work for the new No. 4 boiler-turbine unit on the south-east of the station, the circulating water discharge tunnels in the center and the substation, left, foreground

Eastlake Plant Features A High Generating Capability In A Most Conservative Unit Building Volume

By SEYMOUR B. ROCK, MECHANICAL ENGINEER, and NEAL F. GILL, MANAGER

Mechanical Engineering Dept., Cleveland Electric Illuminating Co.

A careful attention through all stages of design to minimum space expenditures has resulted in a value of 17.5 cu ft of building volume per kw of capability for boiler house, turbine room and electric bay. Further, final overall cost will not exceed $122 per kw of capacity. Annual net heat rate, 1954, was 9386 Btu per kwhr.

IN ORDER to meet the rapidly growing demand for electrical energy in the Cleveland-Northeast Ohio area, The Cleveland Electric Illuminating Company in 1951 planned the construction of its first entirely new plant in over twenty years. The ultimate planned capacity of this plant was to be one million kilowatts.

In deciding whether a new plant should be built, rather than expand existing facilities, a long range study of load growth in the system area was made. The cost of adding large blocks of capacity at existing plants proved to be higher based on long range system growth requirements than the costs which would be incurred by an all-new plant.

Several possible plant locations along the lake shore east of Cleveland were inspected. The area finally chosen was a 162 acre site, located near the mouth of the Chagrin River, 22 miles east of downtown Cleveland. The site was selected because of its proximity to the 132,000-volt tension lines which connects the three other electric plants in the system. The plant location is also near the center of a rapidly growing load area on the system, and therefore would further tend to reduce transmission losses.

Circulating Water System

With the plant location established it was necessary to consider the arrangement of plant and plant facilities on the site selected. Because of the location on an exposed strip of shore line, it was necessary to construct sheltered circulating water intake and discharge chan-

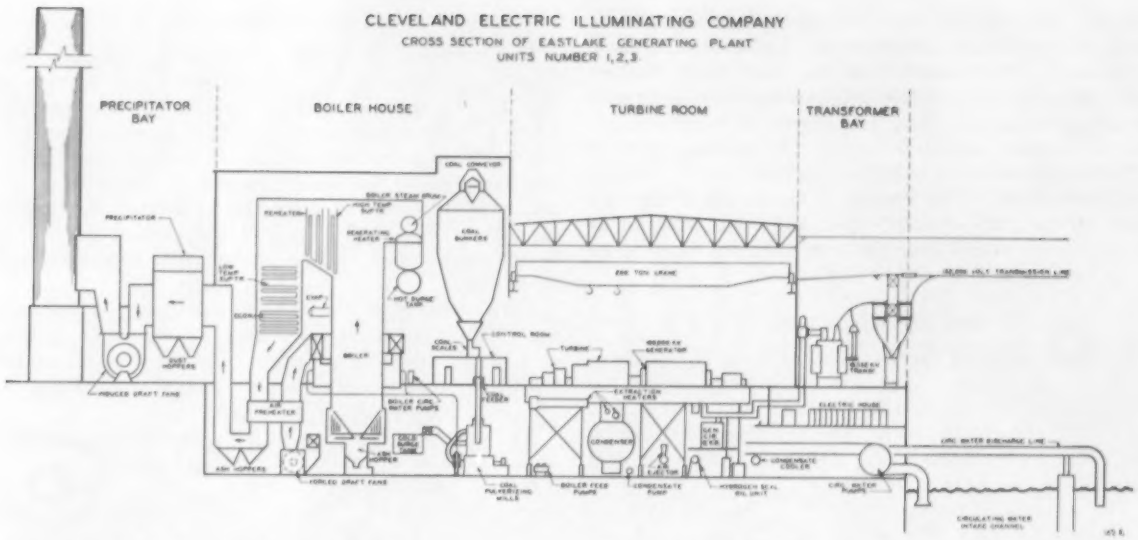


Fig. 2—Simplified drawing of steam boiler and turbine generator arrangement illustrates the location of major plant equipment at or near ground level which helped produce a small building volume of 17.5 cu ft per kw of capability

nels. At that time the decision lay between tube or open channel construction. The latter was chosen because the water needs for the station's planned ultimate capacity would require too heavy a capital outlay for the quantity of tubes involved. The use of channels eliminated the need for any tunnels except those for the coal conveyor system.

The intake channel consists of two cellular parallel breakwalls extending 1200 feet directly north into the lake. (*See Cover photo.*) The discharge channel is protected on one side by a cellular wall extending 400 feet in a northeasterly direction. The other side is a straight sheet pile wall which serves the additional function of shore protection. Both channels were dredged to a depth of 15 feet below mean low water level. A gravel and sand mixture was used to fill the cells and a concrete cap was installed. This arrangement of marine work provides for a water supply free of turbulence and also protects the shore line from erosion.

In orienting the plant on the site 41 basic arrangements of the major equipment were studied. After consideration of the economies of each of these arrangements, it was decided that the main axis of the plant should be perpendicular to the lake front. The first unit would then be located on the shore side of the plant and succeeding units would be built away from the lake. This system would take advantage of reduced construction costs as the contruction moved away from the lake front. The intake and discharge circulating water channels were continued inshore and can be extended at minimum cost as future units are added to the plant. This intake and discharge system is now capable of handling 1,000,000 gpm.

Since all of the Company's previous postwar construction had been additions to existing plants, the building arrangement of those units was, to a large extent, dictated by the existing buildings. At Eastlake, however, it was possible to choose the building conformation best suited to modern power plant practice. Accordingly all designs—outdoor, semioutdoor and fully enclosed—were studied. It was found that the so-called "ranch-type" construction would yield the best results at lowest cost and, for our locale, fully enclosed construction seemed most attractive. All major pieces of steam generator equipment were located at or near ground level, Fig. 2. These items include the air preheaters, electrostatic precipitators, forced and induced draft fans, pulverizers and stacks. Locating heavy auxiliaries at ground level permited a substantial reduction in the structural steel in the building framework and installation and maintenance of the equipment, as well as minimizing vibration problems caused by rotating machinery.

Building Features

One of the principal factors contributing to the low over-all cost of the Eastlake Plant is the unusually low building volume for a generating station of this capacity. Throughout all phases of design careful attention was paid to keeping the building volume as low as possible in consistency with safety and accessibility in operation and maintenance. As a result, a value of 17.5 cu ft per kilowatt of capability was achieved for boiler house, turbine room, and electric bay. If all structures are included, some of which are suitable for an ultimate capacity of 1,000,000 kw, this figure becomes 20.3 cu ft per kw. All equipment with the exception of the upper portion of the ash precipitators, the main oil breakers, and the step-up and main house transformers are enclosed. All permanent walls consist of salt glazed tile on the interior and brick on the exterior. The decision to fully enclose the plant was made because of the severity of the winter weather and the desire to keep plant noises reaching the surrounding residential area to a minimum.

Ventilation and combustion air is supplied to the building through a series of louvres located on two of the outside walls near the ground level. The incoming air passes over heating coils which are capable of heating up to 750,000 cfm of outside air from 0 degrees F to 45 de-

grees F. This air then rises through the building absorbing heat lost by radiation from the boiler and auxiliary equipment. The forced draft fan duct inlet, located near the top of the building, receives combustion air at a temperature greater than 110 degrees F. As circumstances require unheated outside air entering through other louvres not covered by heating coils may be blended with heated air. This system of air supply assures an adequate quantity of combustion and ventilating air at proper temperatures over the wide range of exterior air temperatures experienced in this area.

Coal Handling System

Coal cars entering the plant are unloaded by means of a rotary car dumper. From the receiving hopper, the coal goes by conveyor belt to a crusher wich reduces it to a maximum size to $1^1/_4$ inch. The coal then continues by belt to the Boiler House where it is distributed to the coal dumpers by means of a belt tripper.

The sections of the conveyor above ground level are supported by two continuous rolled beams and are enclosed by semi-circular sections of corrugated aluminum. This type of conveyor gallery construction, new to our system, has resulted in substantially reduced fabrication, erection, and maintenance costs and has worked out very satisfactorily.

The coal handling system is designed to deliver 1200 tons per hour to the coal bunkers while simultaneously delivering 1200 tons per hour to the coal storage yard, Fig. 1. Coal for storage is diverted to the yard before crushing and is delivered to the pile through a cantilevered telescopic chute. Mobile equipment is used to distribute and compact the coal on the storage pile. The coal is also recovered by this mobile equipment which delivers it to a reclaiming pit. From this pit it is carried by conveyor belt to the main belt leading to the crusher. Studies have indicated that a cost reduction of approximately 50 per cent is obtained by handling storage coal in this manner in lieu of a gantry crane system.

Provision is made for thawing frozen coal cars before they reach the rotary car dumper. This is accomplished by a series of 40 cast-iron tube radiant oil burners installed on the railroad ties. Twelve luminous flame-throwing oil burners installed parallel to and adjacent to the railroad track also assist in this operation. It is expected that this installation will be capable of maintaining, on winter days, the flow of coal required for full load operation on winter days.

Steam Generation

Each of the three controlled circulation steam generator units, Fig. 3, in the plant is capable of furnishing steam up to 875,000 lbs per hr of steam at 1,050 degrees F and 1800 psig with reheat to 1,000 degrees F. Each of these divided wall units consumes approximately 53 tons of coal per hour which has been pulverized in three Raymond bowl-type mills. A fourth mill was installed in order to be able to do mill and fan maintenance without reducing capacity on the unit.

Each 300 foot steel stack is supported by a series of concrete caissons, sunk 56 feet into the ground. Considerable research in a wind tunnel plus a number of tests at other plants have indicated that this height of a stack should avoid air pollution problems under all normal wind conditions.

Turbine Generators

The turbines are tandem-compound triple-flow and have a capability of 140,000 kilowatts and operate at this load whenever system load conditions permit. There are three high pressure, one deaerating, and two low pressure extraction stages on each turbine. The two low pressure heaters are located in the neck of the condenser to conserve space and to shorten the runs of the extraction piping. Each of the contact deaerating heaters is equipped with an internal direct contact vent condenser.

Each of the 60,000 sq ft main condensers is equipped with 10,100 red brass tubes and is designed to operate at 1 in. Hg absolute pressure. Air removal is accomplished by rotative dry vacuum pumps with steam jet air ejectors available, if necessary.

The generator of each unit has a maximum capability of 156,250 kva at full 30 lb hydrogen pressure and has a rated terminal voltage of 18,000 v. The design short circuit ratio is 0.90. The hydrogen cooler receives cooling water at a maximum temperature of 95 degrees F. To provide for this temperature during periods of higher condenser pressure, a condensate cooler has been added to the cycle which utilizes lake water to cool the condensate going from the condenser hotwell to the hydrogen cooler. Generator voltage is regulated automatically by means of a motor-driven amplidyne generator.

The main 132 kv transformers are located on an outdoor platform immediately adjacent to the generators, Fig. 2. These transformers are single rating forced oil type with water cooling. Transmission facilities include a structure located across the circulating water channels and four 795,000 circular mill ACSR circuits. Service to station auxiliaries is at 2300 volts.

A single separate electric control room is located on the

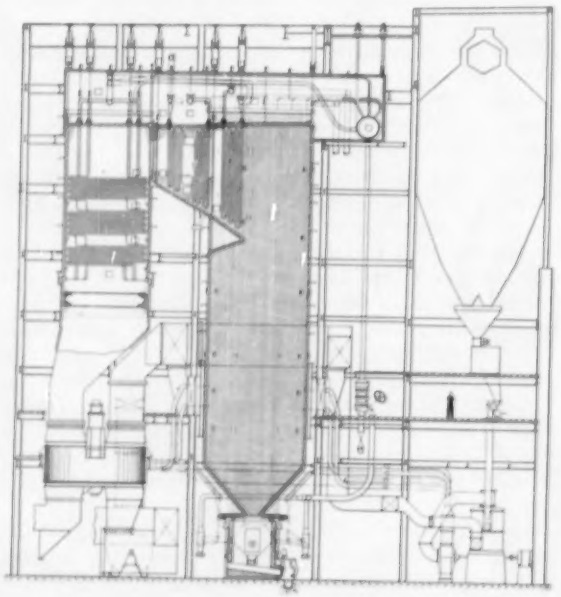


Fig. 3—Cross sectional view of one of the three controlled circulation boilers. Each serves a 100,000/125,000 kw turbine generator operating at 1800 psi, throttle pressure, and a primary steam temperature of 1050 F, reheat to 1000 F

main operating floor level and is expected to serve the entire plant. There are glass windows looking out into the turbine room, along the transformers and main oil circuit breakers, and across the circulating water channels to the 132 kv switchyard, Fig. 1. The room is air-conditioned and completely equipped so that the operators need not leave it.

Control boards are arranged in a segmented circular fashion about the operator's desk. All main electric control and relay boards are in this room and face the operator. One group of boards is used to control the generators while another group is used to control the transmission substation. The circuits supplying the 2300 volt boards are controlled from the generator benchboards. Here again the unit system idea is followed.

Each steam control room serves two boiler-turbine units and is located centrally between them. Windows are provided for direct observation of the major units. In designing the controls provision was made for the highest degree of automatic control of equipment consistent with safe operating principles. This philosophy permits a substantially smaller operating force than was heretofore possible while still providing for periodic visual inspection of key points in the plant. It also permits immediate personal attention to any trouble spot which may develop. The decision to separate steam and electric controls was based on the lower man-power requirements for our particular conditions.

Each boiler-turbine unit is controlled by one operator from a benchboard equipped with miniature instruments. Indicating and recording instruments are mounted on the control room walls. Key measurements are indicated or recorded in two places to afford protection against instrument failure. Pressure and flow measurements are transmitted to the control room pneumatically, permitting the elimination of all high pressure tubing in and around the control room. In addition to the control room operator, there is one roving operator assigned to each boiler-turbine unit. A third man is assigned to remove ashes and mill rejects from all the units. This post is not duplicated.

In designing Eastlake Plant, minimum energy costs have been obtained by the selection of efficient generating equipment and by careful engineering of structures and equipment. Final overall cost of the plant will not exceed $122 per kilowatt of capability (140,000 kw each). (This cost includes rail, coal storage, service, and offshore marine facilities designed for the ultimate-sized plant.) An annual net plant heat rate of 9386 Btu per kwhr has been experienced during the year of 1954. Eastlake Plant generated 40.4 per cent of the total net system generation.

The present force consists of 115 men for the three-unit plant, or 0.275 men per mw of capability.

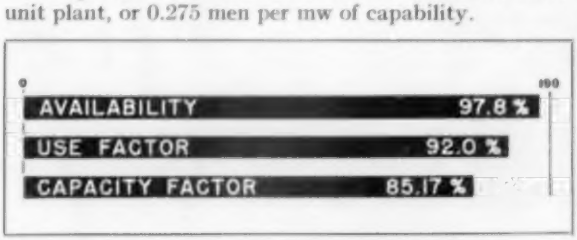


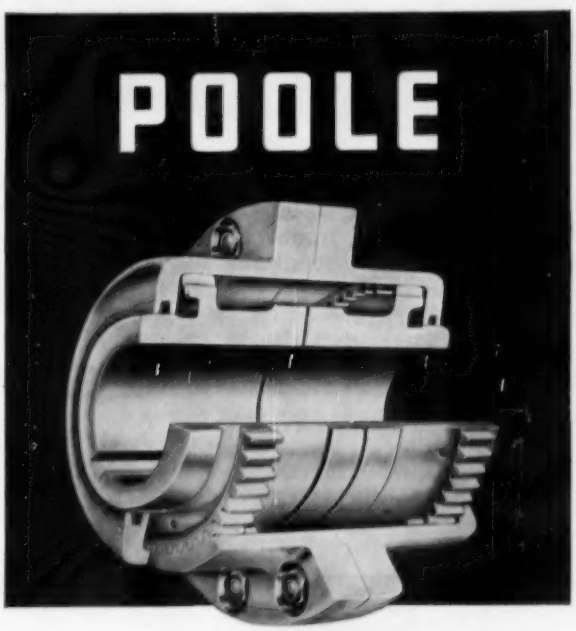
Fig. 4—Excellent station performance record is reflected in the above bar charts which portray availability figures, use and capacity figures for the controlled circulation steam generators at Eastlake

Ground was broken for Eastlake Plant in January 1951. The first unit went into service 32 months later. The second unit followed in three months. Unit No. 3 went on the line early in September 1954.

Operating Experience

As the above record indicates plant experience to date has been excellent. The high availabilities of the major equipment—turbines and auxiliaries, steam generators, coal handling equipment—have contributed strongly to this experience record. The series of bar charts, Fig. 4, depict the details of this availability record for the controlled circulation boilers. Overall boiler availability for Units 1 and 2 based on 12 months and 8 months experience, respectively plus Unit 3 on the line 128 days is pictured in the top bar. The use factor, or ratio of in-service hours to total hours, is portrayed in the second bar. The capability factor record, third bar, is the ratio of average hourly output—new kw—to rated capacity of steam generators and explains to a large measure the high percentage of system generating needs delivered by Eastlake and the likelihood of more in 1955.

The station design, engineering and general contracting were carried out by Cleveland Electric Illuminating Co. personnel. In addition all scheduling, purchasing and supervision was furnished by the utility's own organization throughout the Eastlake Plant's construction.



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FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY WOODBERRY, BALTIMORE, MD.

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Problems in Deaeration of Boiler Feedwater

By H. A. GRABOWSKI, H. D. ONGMAN, W. B. WILLSEY and W. NELSON

Research Department, Combustion Engineering, Inc.

This article presents data concerning oxygen content in feedwater supplied to high-pressure boilers and indicates some of the sources and operating conditions which lead to the oxygen contamination of feedwater. Experience has shown that the principal increase in oxygen content occurs during off-peak hours when tests are not conducted by plant personnel. Accordingly, test data representing the entire day's operation have been accumulated in order to evaluate the role of oxygen in the steam plant corrosion cycle

MANUFACTURERS of deaerating equipment have had to improve the air removal capacity of their apparatus in order to meet the stringent specifications set for higher pressure operation. Formerly, the oxygen content in the water from a deaerating heater was specified as not to exceed 0.05 ppm. Today, the guarantee specifications require that the oxygen content must be reduced to below 0.01 or 0.005 ppm in the feedwater supplied to the boiler.

All of the data necessary to establish (1) the maximum concentration of oxygen that can be tolerated in the feedwater and (2) the contribution of oxygen to the corrosion of steel in contact with steam and water are not available at this time. In the absence of complete data, a practical approach, that of reducing the oxygen to an absolute minimum, has been adopted by the designers of steam power plant equipment.

In spite of improvements in deaerating equipment and the development of precise control techniques, corrosion due to oxygen has occurred in a number of high-pressure boilers. It has been necessary to supplement the mechanical deaeration with a chemical de-oxygenation by the addition of reducing agents, such as sodium sulfite and hydrazine, to the feedwater.

The Oxygen Problem

The most serious cases of corrosion have been observed in stations where there is marked reduction in steam requirement during offpeak or night operation. Trouble has appeared in a station where a high pressure system was tied in with an existing old, low pressure group of boilers.[1,2,3*]

Determination of oxygen in feedwater, in a majority of boiler systems, is made once a day. In a number of plants, the oxygen content is analyzed once a week. The analysis of oxygen is generally completed during the day shift when the steam load is constant and the operating conditions are at an optimum. While this value serves as a guide in operation, it also creates a false impression that the oxygen removal is complete during the steaming period of the day or the week.

A great emphasis is placed on obtaining the most accurate analytical procedure for oxygen. There is merit in utilizing the most precise techniques. However, to what avail is this concentration of effort if the analyses are not completed so as to represent operation during the 24-hour period? During a preliminary survey of various utility stations and industrial plants, of the oxygen content in the feedwater, the consensus was that the oxygen content was always low. Values corresponding to the guarantee specifications were frequently cited as being typical of the entire daily operation.

The preliminary survey indicated that a spot check for oxygen would not be suitable in the evaluation of the deaerating efficiency found in a plant. To obtain a continuous determination and recording of oxygen in the feedwater, a Cambridge analyzer and recorder was utilized throughout the study. The accuracy of the instrument was checked frequently by the most precise techniques. It was found that oxygen in the range of 0.003 to 0.01 ppm could be determined with precision. The reproducibility of the analyzer was more dependable than the time consuming chemical analysis. The principal advantage in the use of this instrument is the ability to distinguish a relative increase or decrease in oxygen during the day's operation. Thus, although it is of value to procure an accurate determination, it is equally important to obtain an indication of change in the oxygen content as the factor in plant operation are varied.

The operating systems investigated utilized various methods of deaeration. The cases used for illustration had the following characteristics:

A. Deaerating condenser. (No external deaerator)
   1. Makeup water was evaporated and added to the vapor side of the low-pressure heater. Condensate additions were taken from a surge tank which floated on the boiler feed pump inlet header.
   2. Evaporated makeup as in 1. Condensate additions were sprayed into the condenser.

B. Deaerating heater.
   1. Makeup water was evaporated and added to the deaerator. Condensate addition was directed to the feed line between the condenser and the deaerator.
   2. Evaporated makeup as in 1. Condensate addition was sprayed into the condenser.

* Numbers refer to bibliography at end of article.

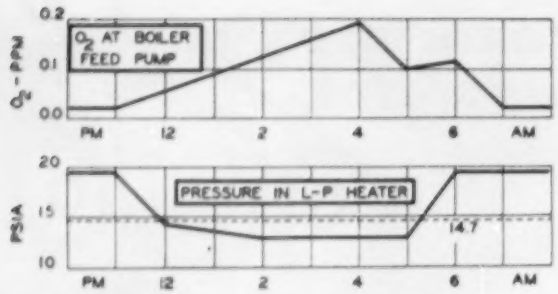

Fig. 1—Oxygen increase due to air leakage in low-pressure heaters

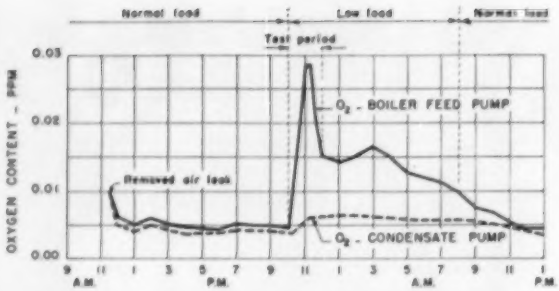

Fig. 2—Oxygen increase at low load operation

3. Makeup water was demineralized and added to the condenser. Condensate was added as in 2.

There is a general disagreement on the relative merits of deaeration with specially designed deaerating condensers and an external deaerating heater. Data was obtained to illustrate oxygen removal capacity with both methods of deaeration. The operating pressure of the deaerating heaters studied varied from 5 to 100 psig. At several stations, the operating pressure of the heater was controlled by the turbine bleed stage pressure. In those instances, at reduced steam loads, the operating pressure of the heater was reduced below atmospheric pressure.

One of the aims of the various investigations was to determine the oxygen content in the feedwater under conditions which were considered to be typical for the particular station. When an operating condition was varied, it was to illustrate the benefit or the adverse effect of a controlled change.

Survey of Plant Operation

During the last fourteen years, a number of papers have been published of tube failures, the cause of which could not readily be explained to the satisfaction of the operator, consulting engineer, and boiler manufacturer. Although the metal attack was attributed to a corrosive action, the reason for the attack was not clearly evident. Measurement of metal temperatures and fluid velocities in the region of failure indicated satisfactory values. An inspection of daily chemical analyses and operating logs did not lend a clue as to the cause of the failure. As a final resource, a survey of operating conditions was completed in an effort to determine whether contaminants may be introduced into a system at intervals that were not completely covered in the plant records.

A. Operation at low loads.

Several factors were found to contribute to the oxygen contamination of condensate and boiler feedwater. Among those investigated were:

1. Reduction of pressure to below atmospheric in feedwater and deaerating heaters.
2. The addition of condensate from surge tanks or clear wells into the feedwater system.
3. Air-removal efficiency of deaerating equipment at reduced load operation.

The results of these investigations are illustrated in the following case histories:

CASE A

The oxygen content in a feedwater system supplying water to a 1300-psi boiler was investigated to determine the oxygen contamination at low load operation. Water supplied to the boiler was deaerated in the condenser. Makeup water was evaporated and directed to the vapor side of a low pressure heater. Condensate requirements were supplied by a surge tank which floated on the inlet header to the boiler feed pump. Under normal conditions, the low-pressure heater operated at a positive pressure. As the steam load was reduced during the night operation, and the evaporator vapor was redirected to the exhaust steam header, the pressure of the low-pressure heater dropped to a value below atmospheric pressure. The heater drips are pumped directly to the condensate line ahead of the boiler feed pump. Fig. 1

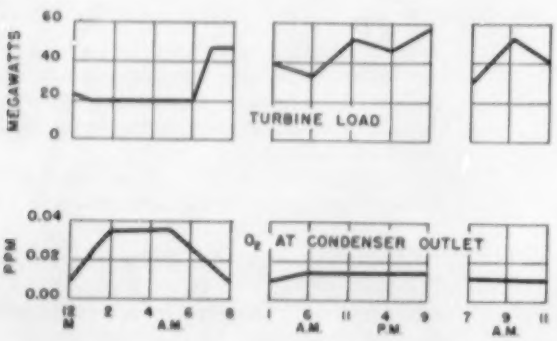

Fig. 3—Oxygen increase at low loads-deaerating condenser

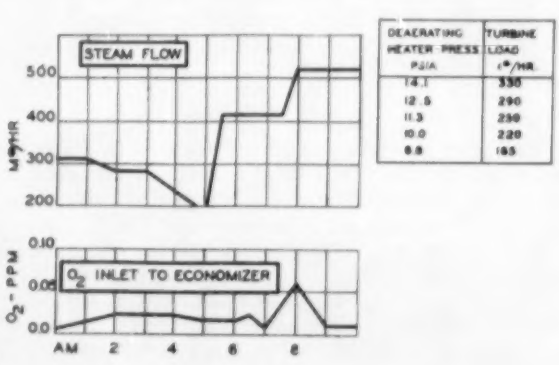

Fig. 4—Effect of drop of pressure in deaerator to vacuum

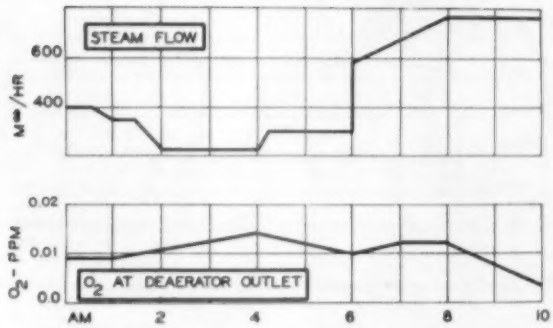

Fig. 5—Oxygen increase during low load operation

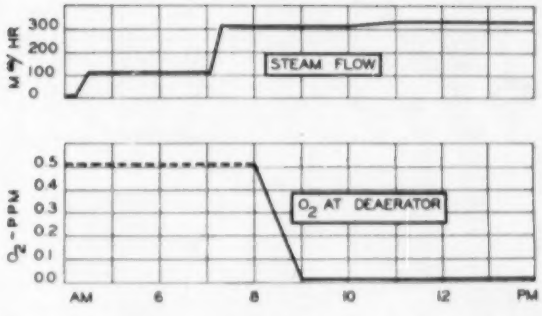

Fig. 6—Oxygen in boiler feedwater during start-up

illustrates the increase in the oxygen content of the boiler feedwater due to the addition of oxygen laden heater drips to the condensate line. When the heater operated at above the atmospheric pressure, the venting of the heater was adequate, and the in-leakage of oxygen did not occur. The increase in oxygen content occurred during each night load. Amelioration of this condition was brought about by adjusting bleed steam to the heater so as to maintain a positive pressure at all times. This operating condition was found in a number of stations where boilers were operated at a reduced load and all the deaeration was completed in the condenser.

CASE B

In many plants where all deaeration is completed in the condenser, the condensate surge tank floats on the suction side of the boiler feed pump. In this position, some operators feel that an extra measure of freedom of loss of water to the boiler is assured in case there is a condensate pump failure. The water temperature often varies between 150 and 210 F. Obviously, when water is introduced into the feed water system from these surge tanks, oxygen enters the system in notable quantities. The effect of the addition of surge tank water into the feed water system of a 900-psi boiler is shown in Fig. 2.

After a review of the results of a preliminary survey, the method of supplying condensate to maintain a constant condenser hot well level was altered. A transfer pump was used to add condensate to maintain the proper hot well level. As a result, a minimum of water was directed from the surge tank to the condensate line. To illustrate the effect of the movement of the surge tank on the oxygen content of the feedwater, the transfer pump was stopped to simulate operation prior to the change. The large increase in oxygen content is apparent. The low-pressure heater was also allowed to drop to vacuum during the reduced night load operation. The increase in the oxygen content of the feedwater above that found in the condensate is clearly illustrated. Fig. 2 also shows the reduction in the oxygen content as an air leak was detected and corrected.

Prior to the oxygen investigation, about 15 lbs of sulfite was added daily to the feedwater. After the corrections were completed, the sulfite feed was reduced to less than $^1/_2$ lb per day. In both cases A and B, the principal introduction of oxygen into the feedwater occurred during the offpeak hours. With the use of the oxygen recorders, it was possible to obtain a record of operation when water analyses were not conducted.

CASE C

There is generally an increase in the oxygen content of the water from a deaerating condenser or deaerating heater when the steam load drops to less than 40 per cent of rated capacity. The increase in oxygen content in the feedwater from a deaerating condenser is shown in Fig. 3. At full load the generator operates at 60 megawatts. As the steam load decreased to less than one-third of rated capacity, the oxygen content increased from about 0.01 ppm to 0.04 ppm.

CASE D

A substantial increase in oxygen has been observed in stations where the deaerating heater is regulated by the pressure of bleed steam. The increase is particularly noted after a period of operation at low load. Case D,

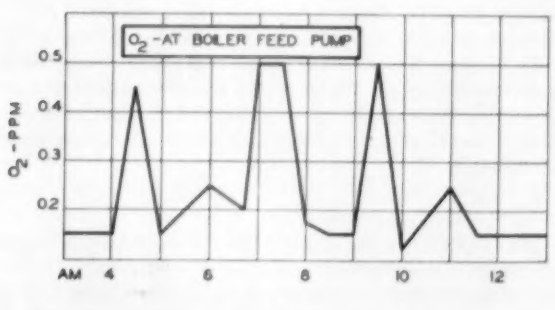

Fig. 7—Oxygen variation during boiler banking

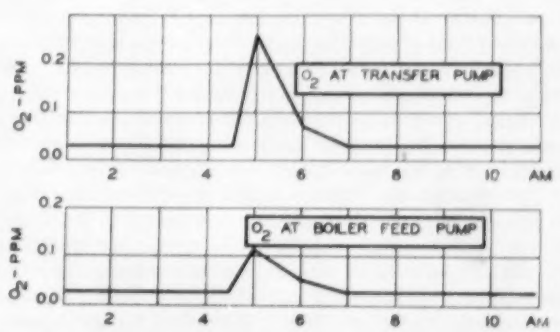

Fig. 8—Oxygen increase due to undeaerated condensate

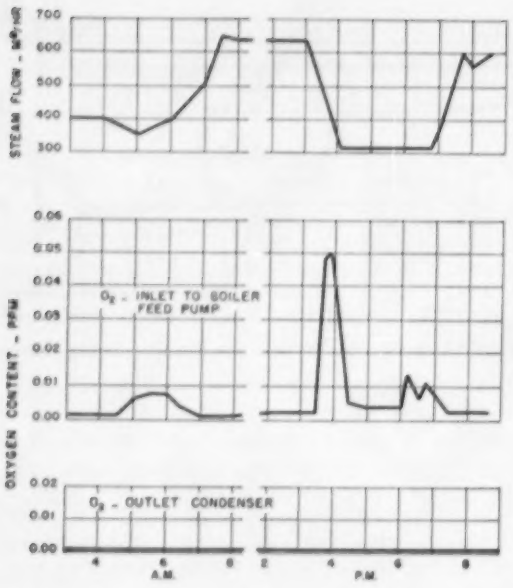

Fig. 9—Introduction of oxygen into the feedwater during fluctuating steam loads

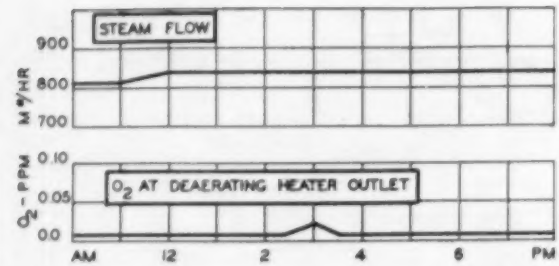

Fig. 10—Effect of large additions of surge water to deaerator

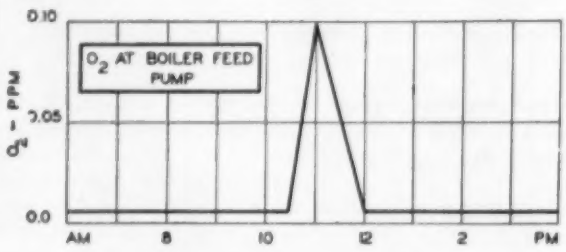

Fig. 11—Effect of insufficient venting before cutting in evaporator

shown in Fig. 4, illustrates the results obtained in a high capacity 1800-psig plant when the load requirement was reduced to 25 per cent of rated capacity. As shown, the pressure of the deaerator dropped to several inches of vacuum at the low load. An increase in the oxygen content of the boiler feedwater was observed at the low load, the major increase occurring during the interval when the steam load was increased rapidly.

CASE E

There is a small increase in oxygen in the feedwater of systems where a positive pressure above atmospheric is maintained and the load is reduced substantially. Fig. 5 illustrates the increase in oxygen of the boiler feedwater to a 1500-psig boiler when the steam load is reduced to 40 per cent of rated capacity. The oxygen increase, from 0.005 to 0.015 ppm, is of a small magnitude.

In the majority of the feedwater systems tested during low-load operation, the principal increase in oxygen was not due to a poorly operating deaerating heater or condenser. The major contamination of feedwater was due to the addition of oxygen laden water at points downstream of the deaerating source. Operation at 25 to 40 per cent of rated capacity resulted in small increase in oxygen in the water from the deaerating source. In general, systems utilizing a deaerating heater contained a smaller amount of oxygen in the boiler feedwater more consistently than those employing a deaerating condenser. On the other hand, the oxygen content in the water between the condenser and the deaerating heater is generally higher than the amount found in the water where a deaerating condenser is used. Under these conditions, a system with a deaerating heater is more susceptible to corrosive action in the condensate portion of the cycle. (*Editor's Note: There is a 5-point summation of design and operating factors at the end of the article.*)

Boiler Startup and Banked Operation

One of the most neglected periods of operation is the startup or shutdown of a boiler. In most instances, the boilers are placed into service during a period of time when there is a minimum of supervision to the control of water conditions. In general, water residuals are not established within proper limits. Similarly, very little attention is given to the removal of oxygen from the feedwater during this period. This apparent apathy to a serious problem can lead to a corrosion problem in a boiler which is removed frequently from service.

CASE F

Fig. 6 illustrates a record of oxygen in the feedwater supplied to the boiler during the start-up operation. It is apparent that the oxygen in the feedwater was greater than 0.5 ppm for nearly four hours after the first flow of steam was started. The oxygen content was reduced to a low residual an hour after full load was attained on the boiler.

Kittredge, (4) in his presentation at the American Power Conference in 1950, estimated the quantity of oxygen introduced into a boiler during a startup. In the example cited in his paper, it was estimated that about 3 lbs of oxygen were fed with the feedwater. In view of such operation one might ask to what avail is the effort to reduce the oxygen content below 0.01 ppm in operation, if we tolerate such large quantities during abnormal operation?

CASE G

Fig. 7 portrays the introduction of oxygen in a higher pressure boiler during a banking operation. In the latter station the feedwater supply is taken from a common header. A surge tank floats on this header. When one boiler is banked and water addition to this unit is re-

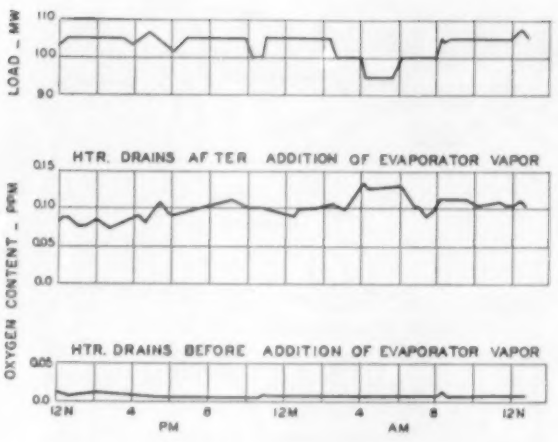

Fig. 12—Effect of misdirection of evaporator vapor. Oxygen added to heater drips by evaporator vapor

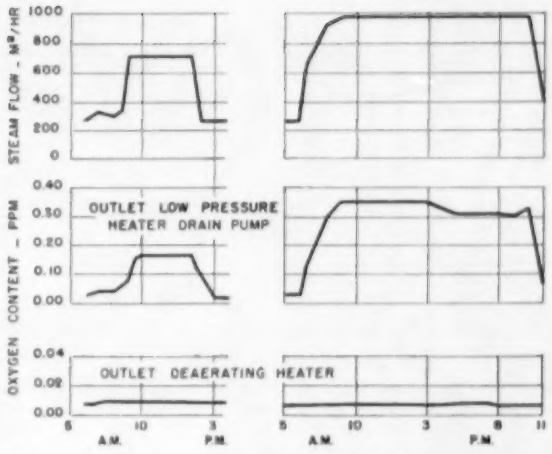

Fig. 13—Oxygen increase in heater drips due to air leakage into turbines

quired, the makeup is taken from a surge tank containing a heated condensate. The increase of oxygen in the water supplied to all the boilers is due to the introduction of an oxygen containing water source. These conditions are rarely recognized because, in many instances, the plant personnel find themselves occupied with other assignments.

Miscellaneous Operating Problems

CASE H

Fig. 8 illustrates a lapse in operation in a high-pressure system employing a deaerating condenser. At this station, steam from the high pressure boilers is used to operate a frequency control unit. The exhaust from the latter turbine is directed to an existing low-pressure system which is generally banked at night. The water to the low-pressure boilers and the makeup to the high-pressure system is taken from a deaerator in the low-pressure system. When the low-pressure boilers are placed into service, the deaerator load is excessive and a larger quantity of oxygen laden water is transferred to the high-pressure system downstream of the deaerating condenser. The large increase in oxygen shown in Fig. 8 occurred daily and was not detected until the survey was started.

CASE I

At another station, where a deaerating condenser is used, an excellent product was obtained at the outlet of the condenser at high or low loads. Condensate makeup to the system is taken from a surge tank which floats on the inlet of the boiler feed pump. Fig. 9 illustrates the contamination of the condensate due to the addition of surge condensate and heater drips downstream of the condenser. There is an appreciable increase in the oxygen content of the feedwater supplied to the boiler at low load operation. It is apparent that the effort to achieve maximum deaeration in the condenser is nullified by the addition of water containing oxygen at the boiler feed pump.

CASE J

A deaerating heater can be overloaded by the addition of a large quantity of condensate at a point between the condenser and the heater. Fig. 10 shows the increase in oxygen content at the outlet of the deaerator at the time a large quantity of condensate is added to the unit.

CASE K

The addition of a poorly vented evaporator vapor to the deaerating heater can result in a notable increase in oxygen in the water from the unit. Fig. 11 illustrates the oxygen increase in the feedwater to a 1400-psig boiler when a poorly vented evaporator vapor is directed to the deaerator after an evaporator cracking period. The oxygen content rose to nearly 0.1 ppm and was high for over an hour.

CASE L

An oxygen attack of feedwater heater surfaces can occur when evaporator vapor is directed to the vapor side of the heaters. Fig. 12 shows the oxygen content in the drains from the low pressure heater immediately below and above the point of addition of the evaporator vapor. In this unit the evaporator vapor and drains exhaust into the vapor side of the low pressure heater. The drains from this heater cascade down to the condenser.

CASE M

Oxygen can also be introduced into the condensate by the addition of heater drips in a system containing poorly operating turbine gland seals. Fig. 13 shows the increase in oxygen content in the low pressure heater drips at high steam loads. At the low loads, the heaters can be adequately vented to the condenser. The bleed steam to the heaters is low and the oxygen content, as shown in Fig. 13, is low.

While it has been indicated that operation at low or varying load conditions can lead to the malfunctioning of the oxygen removal apparatus, oxygen can be introduced into high-capacity boilers during periods when the deaerating equipment is performing as designed and guaran-

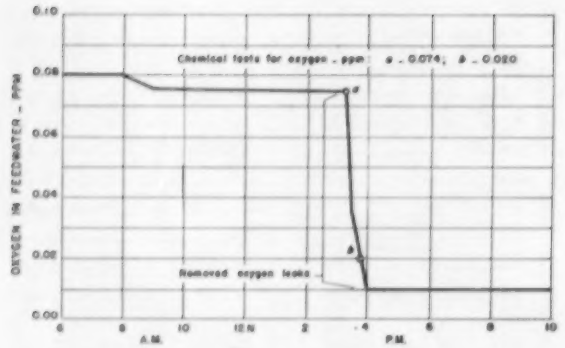

Fig. 14—Detection and removal of oxygen leaks in valve and gland connections ahead of condensate pump

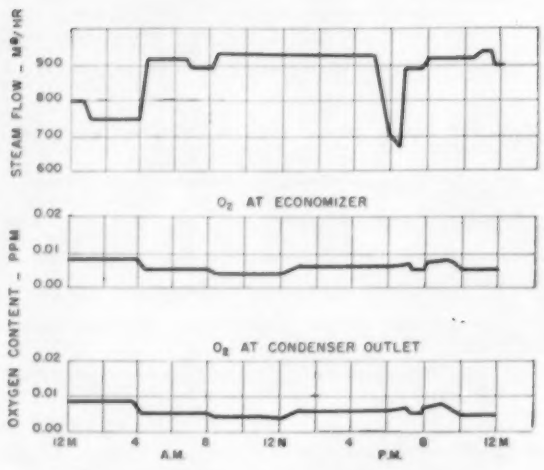

Fig. 15—Oxygen content in the condensate and in the feedwater with varying load; deaerating condenser used

teed. In two large units operating at pressures above 2000 psig, and employing deaerating condensers, an appreciable increase in the oxygen content in the water at the boiler feed pump was indicated by recording and analyzing apparatus. Fig. 14 shows the oxygen content at the boiler feed pump. Chemical analysis checked the recorded values closely. As the air leaks into the system were detected and removed from gage glasses, conductivity cell connections and gland packings between the condenser and the condensate pump, the recorded value dropped as indicated in Fig. 14. After the corrections were completed, the guaranteed oxygen content was obtained.

The data shown in Fig. 15 is presented to illustrate the accuracy and reproducibility of recorded results. Two separate analyzers, one at the condenser outlet and the second unit at the inlet to the economizer, were installed in a feedwater system. Where all the deaeration occurred in the condenser and the oxygen content was low, the agreement in results is clearly visible.

Chemical Control

In the majority of the steam generating systems, a reducing agent such as sulfite or hydrazine is used to remove trace quantities of oxygen. The greatest number of plants use sulfite as the scavenger for oxygen. Tests have shown that the latter when added continuously in a dilute solution, and maintained at a low concentration, in the boiler water, will reduce the corrosion potential in the boiler.

The use of hydrazine has been reported by E. Fiss (5) of Duke Power Company at the American Power Conference in 1954. The period of use of the latter chemical has been short and reservations relative to its adequacy must be made pending future results. Its decomposition tendency at the higher pressures has been established and its addition to feedwaters has been in quantities approaching the stoichiometric requirements for reaction with oxygen. The data obtained in a number of surveys did not show a reduction in the oxygen content in the feedwater when sulfites or hydrazine were added continuously in small quantities. The addition of a cobalt catalyst to the sulfite did not result in an improved chemical reaction as indicated by plant tests. The principal corrosion in feedwater systems, where the oxygen content is relatively low, has been shown to be due to the low pH maintained.

Summary

From the results of the investigations, the following are indicated as design or operating factors which contribute to the oxygen problem in a power cycle:

1. Introduction of undeaerated or partly deaerated condensate to the feedwater. This pertains in particular to systems where surge tanks float on the feed pump suction or in plants where condensate is transferred from a low to a high pressure system.
2. Feedwater heaters which operate normally under positive pressure but drop to vacuum at light loads. Most of the systems tested showed an increase in oxygen where heaters which operate over a range of positive and negative pressures are used.
3. The addition of heater drips directly to the condensate system. In systems with deaerating condensers, it increases the oxygen in the water to the boiler. In systems with deaerators, it increases the corrosion potential between the condenser and the deaerator.
4. The addition of an improperly vented evaporator vapor to a deaerator after an evaporator cracking period.
5. The presence of excessive turbine gland seal leaks.

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Research in the Electric Power Industry*

By L. R. GATY

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This paper reviews briefly the electric power industry, the research it has done and is doing and discusses areas of research which should be pursued more aggressively. The industry must provide the highest service reliability at the lowest cost consistent with sound practice. Any research that holds promise of fostering this objective should be considered and encouraged either directly or indirectly.

THERE is no question of the need for research. It is the key that has unlocked many secrets of nature for the benefit of mankind. There is every reason to believe that we have just begun to tap nature's storehouse and that new developments and knowledge that lie ahead will dwarf the progress made up to date. Research will enable us to enjoy a steadily rising standard of living. It was research that created the electric power industry and it is proper to examine what part the utility industry should take in an aggressive research program. Certain types of research have been and are being conducted by the utility industry and these will be continued and expanded. There are other types of research that have no place in a prudently managed utility company and these will be avoided. Between these two is a broad band of controversial activity that must be carefully considered.

Many Kinds of Research

Our language is woefully inadequate to convey a common understanding of a simple statement. Psychologists tell us that a word or phrase will bring various associated ideas to the mind of the hearer. The simple word blue may be associated with the sky by one person, with someone's eyes by another, and with a deep placid pool by another. What does research mean to you? Does it bring to mind a white frocked chemist in a laboratory filled with test tubes, or a scientist working with various complex electronic equipment, or possibly a doctor using a microscope to examine samples of living tissue. Certainly all these are research but there are many others and to have a meeting of our minds we must be more specific and delineate our areas with care.

Research is defined by Webster as a "careful or critical inquiry or examination in seeking facts or principles; diligent investigation in order to ascertain something." Starting with this broad definition I will give my definition of "fundamental research," "basic research" and "applied research." "Fundamental research" is seeking knowledge of the fundamental laws of nature without regard to the usefulness of the knowledge. "Basic research" is taking this knowledge of natural laws and applying it for the benefit of mankind. "Applied research" is seeking ways to improve a product, reduce its cost or broaden its usefulness.

Research Being Done By Industry

Considered in the light of this definition there is a very substantial amount of research carried on by the electric utility industry. Much of this might have been carried on by industrial concerns or by universities but was initiated by the utilities before other groups became interested. Many of these should have been included in the category of research but were not so classed. These include work in the technical and scientific areas and frequently extend well beyond the scope of work usually associated with this industry.

A few of the research projects now active or completed within the past few years are listed below. This partial list indicates the variety of problems being investigated by research supported either fully or partially by electric power utilities.

Research on graphitization of steam piping

An investigation of the phenomen of graphite migration and means of prevention sponsored jointly by Edison Electric Institute (EEI) and the Association of Edison Illuminating Companies (AEIC).

Branch circuit overcurrent protection

An investigation of the characteristics and requirements of Branch Circuit Protection sponsored by EEI and AEIC and conducted in cooperation with the Underwriters' Laboratory.

Pipe type underground cable research

An investigation of factors affecting the rating and operation of high voltage pipe type underground cable systems by EEI and AEIC.

Heat pump studies

The joint AEIC/EEI Heat Pump Committee has sponsored several studies of various phases of the problem including heat storage media. The committee is now carrying on a preliminary investigations of supplemental heat sources including solar heat.

Steam contamination

This research was organized to study the factors which govern the introduction of impurities into steam from the water in the boiler and the subsequent deposition of those impurities on the blades of turbines. It was sponsored by EEI, AEIC, boiler manufacturers and turbine manufacturers and involved fundamental studies in a little known brand of physical chemistry and the development of new measuring techniques.

*Presented the Winter General Meeting of the American Institute of Electrical Engineers, New York, N. Y., January 31–February, 4 1955.

In addition to the above, active research has been carried on in the following fields as well as others not enumerated.

Electronic accounting machines for billing
Artificial resuscitation
Load characteristics
Furnace performance factors
Atmospheric contamination
High temperature steam generation
Welding
Fly ash

The Cable Engineering Section AEIC has been very active in exploring many factors which affect cable rating, life and operation and has received excellent cooperation from the cable manufacturing companies. Preliminary work has been done on investigating the possibility of using extra high voltage cable. With presently available insulation it appears as though cable would have a very low load rating at 345 kv and could carry no load at 380 kv due to high dielectric loss. Research which pointed the way to a substantially lower dielectric loss in the cable insulation would improve the performance of existing cables and permit an extension to voltages in the 300–400-kv range.

In addition to these direct projects there have been many carried on by various technical committees of industry organizations. Our industry is unique in its policy of free interchange of information among its member companies. Troubles and errors are frankly discussed and all information made available to other companies having the same problems or equipment. A catastrophe may occur on one system and within a matter of hours it is known and the high lights made available to other companies. Visitors will arrive and be given full information, and later these troubles fully discussed and analyzed at committee meetings. In addition, innovations, improved methods, better utilization of equipment and economic simplification are discussed and the full story made available to all interested. This atmosphere of frankness and mutual interest has created a committee organization of unusual effectiveness. It permits the entire industry to benefit from the pioneering of each member and allows the group to go forward with accurate scientific knowledge. Without this free and frank interchange the progress to higher voltage, larger units, greater capacities, higher temperatures and pressures would have been much slower. The industry does not call this activity "research" but certainly it is included if we refer to the definition.

Progress Through Cooperation

There are various needs that must be weighed and evaluated. The utility industry needs a healthy and aggressive equipment manufacturing industry and an aggressive utility industry is essential to a continuing improvement in our living standards. Both of them need a healthy, aggressive, alert and forward looking group of technical educational institutions. They provide the lifeblood of both industries through the new talent that is trained. Without a virile and progressive educational program we cannot continue to progress as we have in the past. Ways must be found to keep the educational institutions healthy and solvent and to attract and hold outstanding teaching staffs. One way of doing this is to authorize research projects that will provide financial support, and equally important, will stimulate interest in the power industry.

The electric utility industry has just passed its seventy-fifth birthday with every indication of a continuing dynamic growth ahead. There is a challenge for the best technical and managerial talent to carry on its traditions and fulfill its obligations. One of the reasons for this success is an extremely close relationship that has existed between the utility engineers and the engineers of the equipment manufacturers. Through the years a cooperative partnership has grown up between these two groups that has resulted in unprecedented progress in new and better products with ever increasing efficiency and reliability. The electric utility industry could not have reached its present stature without the developments that have stemmed from this teamwork and the research and standardization that has been made possible. New designs, higher efficiency, greater economy, better reliability, simplicity of operation have all resulted from this partnership and have permitted cheaper and more reliable electric power to become one of the miracles of our industrial expansion. All groups have shared in the benefits of this teamwork and any program of research must not interfere with it.

The equipment manufacturing industry has provided research laboratory facilities and personnel to carry on an aggressive program of research. The fields of investigation are broad and include metallurgical, chemical, electrical, thermodynamic and others. This has many advantages to the manufacturer and his customers. It makes available the results to a wide group, it strengthens the sponsor, it provides excellent facilities and technical talent to investigate a problem that may develop suddenly in connection with new products or new applications and it provides lower costs for the manufacturer that can be passed on to the customer along with a better product. Competition tends to increase the effectiveness of this arrangement and makes it far more productive than a single research center supported by many sponsors. There is nothing that provides a greater incentive than having a competitor get a temporary advantage through improvements in his product. It is a characteristic of the American buyers that quality and performance are far more important than price.

This research program must not be upset. It is proper that certain types of research should be conducted by the manufacturer and not by the purchaser. The customer should not be expected to do the research to improve the product he is purchasing, although he should make sure the product is the best for the application he has in mind.

The industry today is producing a kilowatt hour for less than half the fuel required thirty years ago. This has not been brought about by any one group but through the combined efforts of the manufacturers of all types of equipment and the willingness of the utility industry to pioneer by purchasing and operating this equipment. Many times there has been a small venture into unknown regions and sometimes it has been necessary to backtrack temporarily. The utility industry has been willing to pay the costs of the necessary research and take the risk of expensive changes. The field modifications made in cooperation with the manufacturer have made many

contributions to progress and scientific knowledge. There appears no other feasible way of doing this type of research—a million-pound-per-hour boiler cannot be set up in a university laboratory for research purposes, and small scale models do not yield typical results. This activity is not called research but it should be. That is undoubtedly one of the things that could have been more widely publicized in the past.

There are many similar projects which must be undertaken on a full scale field basis and the research work done after operation starts. Naturally there are many components that must be designed, analyzed, tested and modified in the shop before fabrication, but the overall operation of the device cannot be accurately determined from component information. The necessary field work and many modifications are fed back into the manufacturer's design group and used to improve future products. This type of research makes a substantial contribution to the knowledge of the art and to the welfare and prosperity of the utility business, but does not get included in the discussion of research activities.

Even though a great deal of research and promotional activity is being carried on by the utility industry and by individual electric utility companies there is certainly ample room for improvement and a substantial expansion in the amount of activity. Dynamic and continuing expansion in the industry suggests that an increase in the level of research activity would be appropriate. There are many cogent reasons why the industry should be providing a more progressive research program. One obvious reason is that inherently the utility industry must obtain a long life from its plant investment. Industrial concerns are able to write off equipment on a short term basis, but this is out of the question for major plant investments of utility companies. Any research activity that will contribute to longer useful life and lower annual cost is highly beneficial.

New Sources of Energy

There is a new source of energy coming to the front—Atomic Energy. More of our national scientific talent is devoting itself to atomic energy for war and peace than has ever been devoted to a single project. The utility industry is vitally interested in this field and is actively conducting research in many directions. A large number of electric utility companies are participating in one or more study groups investigating atomic energy in all its peacetime power producing aspects. Chemical, metallurgical, thermodynamic, mechanical and economic factors are weighed and investigated. This work is being done in the laboratories of universities, industrial concerns and research foundations. The recent changes in the law will permit greater use for peaceful purposes. The utility industry is now well advanced in its knowledge in this field and fully expects to continue on to the installation of large scale atomic energy applications.

This immediately brings to mind an item that has recently received wide publicity and has caught the fancy of the public. The conversion of solar radiation to electrical energy has been improved and widely heralded. How does this affect the utility industry? Some of the semi-scientific writers have envisioned a solar converter on every housetop with unlimited power available for all household uses including heating and cooling of the home. We can say without fear of contradiction that with present knowledge, materials and costs this is only a dream. But as research adds to knowledge and provides new materials the dreams of the visionaires are often realized or exceeded. Certainly the utility industry must keep abreast of all new developments in this field.

There may be other new forms of energy or energy conversion that will appear in the future. When these are discovered through research the electric utility industry must keep abreast of the developments and be ready to use them to supplement the older forms of energy conversion. This may require a research program to apply the knowledge and make the energy commercially useful but the industry should not embark on a program of fundamental research to discover such energy sources.

Progress Through Dissatisfaction

The progress that has been made in the past fifty years can be keynoted as due to "dissatisfaction." The customers are eternally dissatisfied with what they have and want something bigger and better. New cars, new clothes, new homes, new appliances, new entertainment, and new roads. The dissatisfaction of the American public has been aggressive and vocal and any concern that does not cater to it will fall by the wayside. This dissatisfaction extends into the factories and utilities. Better machine tools, better quality control, and better working conditions are always being striven for. The utilities are dissatisfied with the service they render, with the equipment they buy, with the engineers educated by our universities, with the cost of equipment and the operating expenses. Always they are seeking a better, more reliable, more economical device that will be simpler and safer to operate.

This dissatisfaction is healthy provided we always strive for something better and not just for something different. Dr. Hobson and Dr. Lewis were dissatisfied with the amount of research that was being sponsored in universities by utilities and had justification for it.[1] Their paper is a provocative and able statement of one of the important problems facing the Electric Power Industry. Very little has been done through this channel and more, much more should be done. But it would be most unfortunate if this did not meet two requirements—first it must be research which will help the utility industry to move forward—second it must be the type of research that can be done properly and effectively by the universities. Dr. DuBridge discusses this subject and points out the advantages of research, the needs for research, but above all the importance of doing the proper kind of research and not merely gadgeteering for the sake of obtaining financial support.[2] Research in a university can make a substantial contribution to the understanding of natural laws and act as a stimulus to additional research by other groups. I, too, am dissatisfied with the amount of research the industry is doing, but I am also dissatisfied with the reliability of service rendered and with the costs achieved. If such

[1] Research for and by the Electric Power Industry, J. E. Hobson and W. A. Lewis, Electrical Engineering, June 1954, page 516.
[2] The Goals of University Research, L. A. DuBridge, Electrical Engineering September 1954, page 790.

research will make a substantial improvement in the service reliability or a substantial reduction in its costs then the problem of the university research groups would be to find facilities and staffs to keep up with the research projects thrust upon them.

Industries hiring technical men have indicated dissatisfaction with both the quantity and quality of the engineers being educated. The electric power industry urgently needs a steady flow of good engineers capable of growth and development. It is essential to stimulate the interest of the teaching staff as well as the students in the opportunities ahead in the power field. One of the easiest and most effective ways of doing this is to provide research projects that will provide financial support for the institution and for the staff and provide mental stimulation for the staff and students. There are many advantages in such a program, the least of which is that it can be at least self supporting and may pay off in substantial direct benefits. In addition it provides financial support for the improvement of physical facilities, it helps to obtain and hold high grade teaching staffs that could not be held otherwise, it provides a real interest on the part of the men who are training and advising the students and it will provide a more adequate flow of well-educated engineers interested in the power business. Such a plan would also provide a pool of consultants conversant with electric power industry conditions and available when unexpected problems arise. There have been many cases where such consultation was desperately needed but was not available or was unknown.

Wide Range of Power Industry

In thinking of the power industry, many people include only the electric utility industry. Brief consideration will show that this is only a part of it and that the field includes the equipment manufacturing industry, all large industries such as mass transportation, automotive manufacturing, mining and much of the entertainment and communication field. New techniques in the electrometallurgical field require tremendous amounts of power. The aluminum industry has some of the largest hydroelectric developments in the world. Television and radio require large blocks of power and color television will increase this manyfold. The power requirements of the fabricating and manufacturing industry are increasing steeply with the need for higher product output with lower costs and fewer men. The large factories have extensive power distribution systems built in with the requirement that they must be flexible enough to meet future changes in manufacturing techniques and power requirements. When we think of the power industry we should give it credit for its full scope.

Cooperative teamwork between the power industry and the educators will provide handsome benefits to both parties. Research provides a medium through which this can be done. There is a broad mutual interest between the educational institutions, the manufacturers, the contractors and the utilities. This mutual interest should provide a strong incentive to work out a reasonable solution benefiting all parties.

Future of Industry

A brief review of the forecasted growth in electric power use by many experts presents a challenge of the first magnitude. Even if we assume that the growth slows down and our load doubles each fifteen years we will have eight times the load by the year 2000. The efficient supply of our customers at that time will require new knowledge in the fields of generation, transmission, distribution, utilization, accounting, and record keeping. Some of these problems are common to other industries but some are unique with the public utility industry. The sooner this knowledge is available the more healthy will be the growth.

Research by the electric utility industry is essential and a way must be found to strengthen and expand the research being supported by the industry. A tremendous job lies ahead of us even if forecasts of future growth are only partially fulfilled and every tool must be utilized to assure that this job is done well. Research wisely conceived and properly channelled is a tool that will assist in this sound growth and help assure that capable technical personnel is available to the industry.

Editor's Note:

The above paper was one of four on a symposium entitled "How Can the Utilities Best Make Use of Research" sponsored by the AIEE at its recently concluded Winter General Meeting, New York, N. Y., January 31—February 4, 1955.

Continuous records of the oxygen dissolved in boiling feed water and of the hydrogen entrained in steam, point to the corrective measures necessary to prevent otherwise unsuspected and costly corrosion. The Cambridge Analyzers measure and record dissolved oxygen directly. The hydrogen in the steam is measure of the oxygen set free by dissociation. Cambridge Instruments are available for recording O_2 and H_2 either separately or simultaneously.

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High Temperature Water Heating System Supplies Dover Air Force Base Needs

Water has long proved to be an excellent heat transfer fluid and the recent increased attention to high temperature water for heating and process reflects the development of system designs which make it possible to utilize the relatively high specific heats of water in and around 300 psig. Here is a description of a large scale high temperature installation at a U. S. Air Force Base.

By M. W. WILLIAMS

Combustion Engineering, Inc.

THE U. S. Air Force Base, Dover, Del., employs a district heating system for the various buildings, warehouses and hangars on the base with a central heating plant serving as the heat source. High temperature water was selected as the most economical medium for distributing the heat.

In essence, high temperature water heating systems are a further development on a larger scale of principles used in countless heating systems for homes, schools and other small buildings. To effect economies on heat transfer apparatus and hot water distribution equipment higher temperatures and necessarily higher pressures are used. Higher pressures were used as early as the 1920's when pressures up to 235 psig (400 F equivalent) were adopted. Since very high temperatures, that is above 380 F, are not often required, except for process heating, the more practical and general range is from 350 F to 370 F. Temperatures above 400 F do not prove economical for district heating service.

High Temperature Water Boilers

The three hot water generators, Figs. 3, 4, selected for the Dover Air Force Base are C-E La Mont controlled circulation hot water boilers designed for 400 psig pressure but operated at 275 psig (415 F equivalent). The specified rated output is 50,000,000 Btu per hr, maximum continuous, when using No. 6 fuel oil of a calorific value of 18,500 Btu per lb, as fired. Each generator is of the watertube type with the boiler tube assembly divided into radiant and convection sections. Each tube circuit is $1^1/_2$-in. O.D. tubing with an orifice located at the inlet end for meter.ng the water in accordance with the heat absorbing capacity of that tube.

Water from the distribution system enters the boilers through the inlet header at the bottom of the boiler in the rear, Fig. 4. The side wall tube platens and the front wall tubes have connecting headers so that the water parallels the gas flow, due to the single pass boiler design, with water leaving the boiler through the front top header and entering the expansion drum that serves more than one boiler. Water from the expansion drum enters the distribution system circulating pumps which discharge it into the system at 375 psig. Fig. 4 does not show the single separately installed expansion drum.

Fig. 1—Exterior view of the boiler plant at the Dover, Del., Air Force Base which can supply with three C-E La Mont controlled circulation boilers a heat load distributed in 98 buildings around the Base

Fig. 2—Heat exchangers have been located in each of the 98 buildings for local building heating needs. Where steam is needed separate heat exchangers are provided. About $14^1/_2$ miles of interconnecting piping are employed

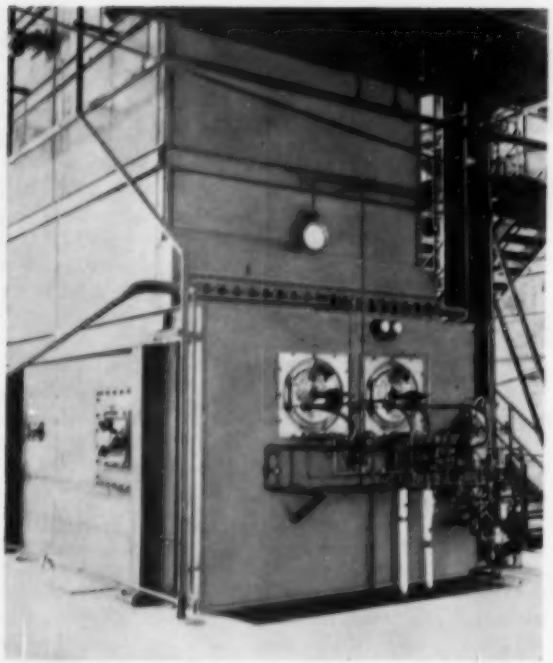

Fig. 3—Compact, fully enclosed design of the controlled circulation boilers, above, permits high degree of shop assembly as well as a conservative use of building space

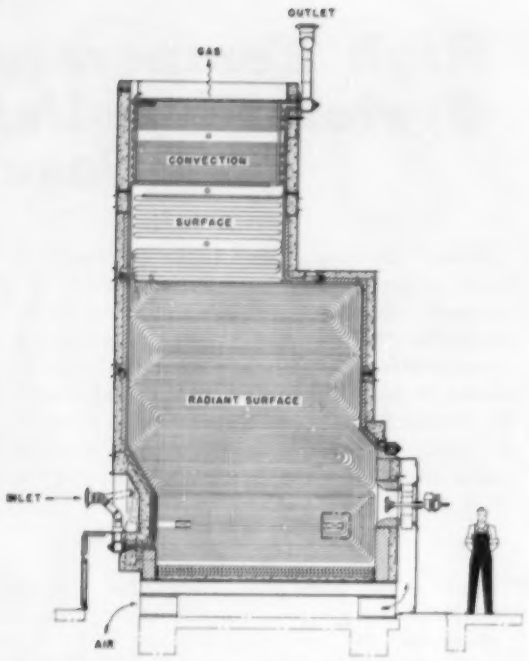

Fig. 4—Sectional view of the C-E La Mont controlled circulation boiler demonstrates its single pass design, freedom from baffles, absence of a boiler drum

Heating Load

At Dover Air Force Base there are 98 buildings requiring heat. Some of these buildings, such as the warehouses, are heated directly with high temperature water at the full pressure in the distribution system, whereas the living quarters, mess halls, and others are heated with low pressure, hot water. These individual heat loads, together with the steam requirements they impose, are listed below:

(*a*) High temperature water at 385 F is distributed directly to the unit heaters installed in the warehouses, hangars and shops.

(*b*) Low pressure hot water heats the living quarters through baseboard convectors, the mess halls by means of unit heaters, the medical buildings with fin tube radiators, the operational buildings also with fin tube radiators and unit heaters, and the special services buildings with fin tube radiators and unit heaters.

This low pressure hot water is produced through indirect heat exchangers, Fig. 2, located one to each utility room. Each of the 98 buildings has its own utility room. The high temperature (385 F) water from the main distribution system passes through the primary coils of the heat exchanger. The low pressure hot water is pumped from the secondary side to the local heating units. The medical and operational buildings will have air conditioning and will be connected into the low pressure heating lines serving the fin-tube type radiators.

Where steam is required, whether it be for cooking, sterilizers or other purposes, a separate high-temperature-water-to-steam heat exchanger has been installed in the building's utility room.

The steam requirements are as follows: Officers Mess Hall—30 psig, Refrigerator Storage—20 psig, Hospital—45 psig, Airmen's Mess Halls—30 psig, Boiler plant—67 psig, Maintenance Shops—30 psig, and the total steam flow amounts to 16,810 lb per hr.

If there were no heat exchangers, a separate boiler would be necessary in each building, requiring a licensed operator or boiler room attendant. Since heat exchangers are classified as unfired pressure vessels, they can be, and are, of course, left unattended except for periodic inspections and servicing visits. This is one of the greatest advantages of a district heating system. With high temperature water, there are other advantages such as the elimination of steam traps, no grading of supply and return lines, no condensate receivers or condensate pumps and a complete return of all unused heat to the central heating plant.

Distribution System

At the Dover Air Force Base, there are three main zones: Zone 1—19,890 ft of piping, Zone 2—35,350 ft of piping, Zone 3—20,850 ft of piping. The total length of these heating lines, excluding internal distribution within the 98 buildings, amounts to almost $14^1/_2$ miles. The main supply and return lines alone total 34,340 feet, the balance being external branches or sub-main circuits.

In steam distribution systems, the system pressure drop is the deciding factor and one which has a direct relation to the diameter of pipe used. With high temperature water, however, it is the design temperature drop which is the governing factor. In low pressure hot water systems for internal hot water space heating, it is usual to design the distribution piping for a temperature drop of 20 degrees F, but with high temperature water

the design temperature drop may be as high as 200 degrees F, although the most commonly used and more economical design drop ranges from 150 degrees to 160 degrees F.

Another great advantage of high temperature water for heat distribution is its "thermal-flywheel" characteristic. This feature develops from the fact that the entire piping system, always maintained full of high temperature water, constitutes a vast reserve heat storage. This reserve effect represents approximately a 20 per cent cushion or safety factor in boiler capacity. As a result boilers can and are designed for the average 24 hour temperature rather than the peak load temperature.

The reserve of heat in the entire system at the Dover Air Force Base may be better understood when you realize the total water in the complete system, including the three operating boilers, is about 700,000 lbs. This is an important asset in an emergency and one of great value when changes or extensions are contemplated.

System Economies

Economies to be affected by using hot water instead of steam are as follows:

1. **No high pressure steam traps required,** resulting in substantial saving in first cost and a further saving by eliminating steam losses likely in normal trap operation as well as attendant maintenance.
2. **Elimination of blowdown,** normally a three per cent operational loss.
3. **No pressure reducing valves needed,** producing a first saving in valve cost, a second in maintenance and a third in steam losses from improper regulation.
4. **No safety valve vent losses** such as exist with a steam boiler.
5. **No condensate pumps, tanks, controls and vents required,** avoiding their inherent steam losses.
6. **Elimination of expensive feedwater treatment system,** with its continuous chemical cost and maintenance. Water makeup for a high temperature water system is negligible and this can be handled with a small batch treatment storage system.
7. **No investment outlays for corrosion protection in condensate return lines,** representing an essential consideration for a steam system but not for a high temperature, water system.

Boiler Advantages

Following the decision to use high temperature water as the heat distributing medium instead of steam, it was also decided to use boilers especially designed for high temperature water, Figs. 3, 4, rather than units designed to generate steam but modified for hot water. Previously, the conventional watertube steam boiler with multiple water passes had been adapted for high temperature water with mixed and not altogether satisfactory results.

The C-E La Mont controlled circulation boiler, Figs. 3, 4, especially designed for use in hot water systems provides the following features:

1. *Controlled circulation* such that water is distributed to the various tubes in accordance with the heat absorbing capacities of the tubes. With this arrangement, a minimum amount of water need be circulated through the boiler with a corresponding minimum pressure loss. With a small increase in head, the system circulation pumps can therefore provide for circulation through the boilers. The need for a separate boiler circulation pump is thereby eliminated thus affecting a saving in initial and operating costs.
2. *No drums* are required on individual boilers. A single expansion drum common to all boilers can be used. This results in a simplification of the control system and eliminates the necessity of providing balance pipes between the various boilers in multi-boiler installations.
3. Special tube arrangement is provided so that:

(*a*) Boiler tubes are *ventable* to the outlet header (and thence to the expansion drum) under all operating conditions. Vapor binding will not occur. Even though a small amount of steam may be formed in the tubes under some operating conditions, it will remain entrained until it separates in the expansion drum.

(*b*) Boiler tubes are completely *drainable*, and there are no reverse vertical tube circuits.

(*c*) The boiler has a single pass design with no baffles, and tube arrangement gives *parallel flow of gas and water*. Low metal temperatures are avoided in zones of low gas temperature thus minimizing the possibilities of corrosion resulting from high sulfur fuels.

(*d*) *Maximum furnace water cooling* and the most effective utilization of heating surface occurs. This markedly lengthens refractory life.

(*e*) *Maximum cleanability* is obtained with *minimum fouling* in operation.

4. Miscellaneous advantages include:

(*a*) Maximum degree of shop assembly thus greatly reducing field erection costs.

(*b*) Complete steel casing suitable for pressurized operation with oil or gas fuels thus eliminating the necessity of induced draft equipment.

(*c*) Bottom-supported design thereby reducing structural steel.

(*d*) Adequate access panels for cleaning, inspection and maintenance of convection bank heating surface.

(*e*) Minimum space required saving in building costs.

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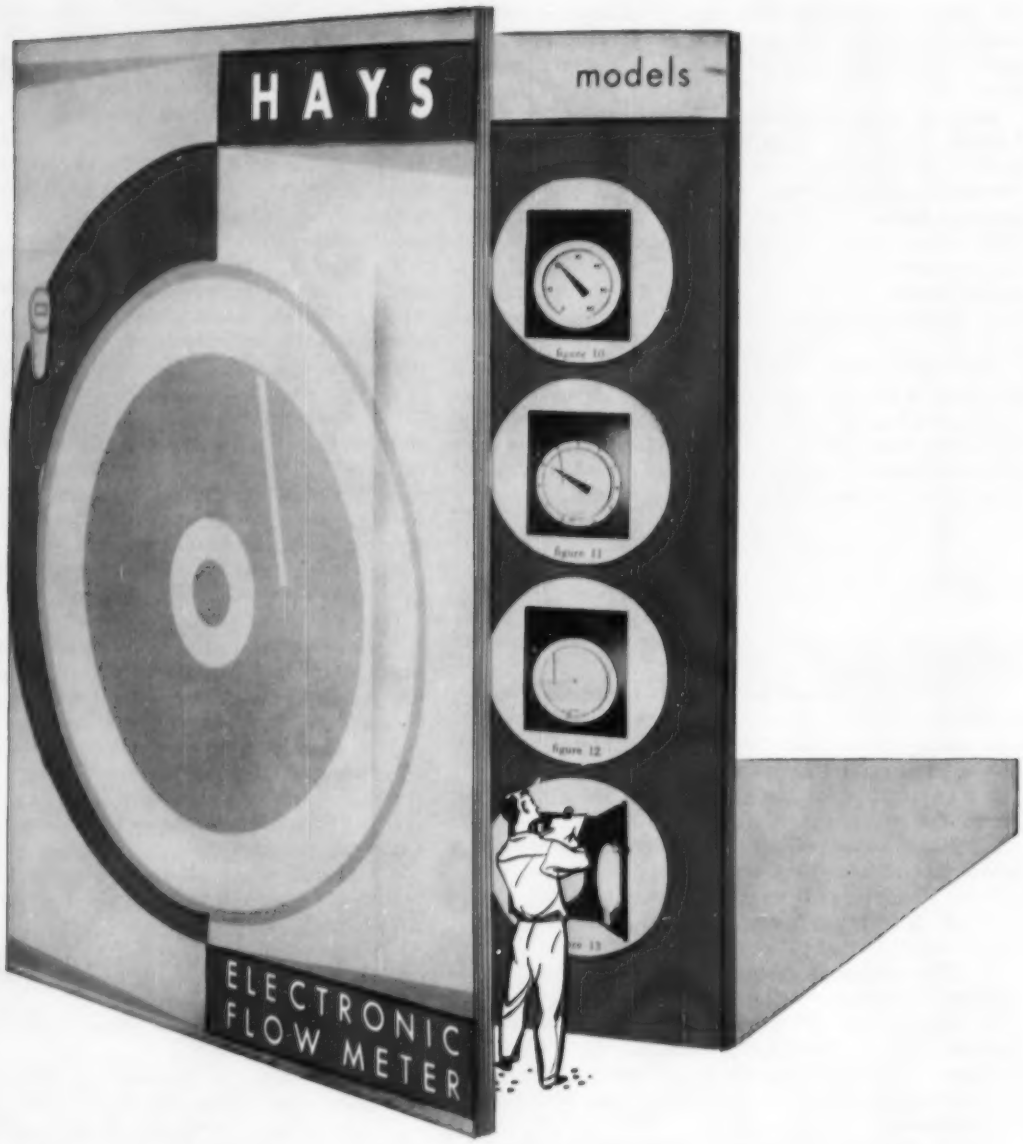

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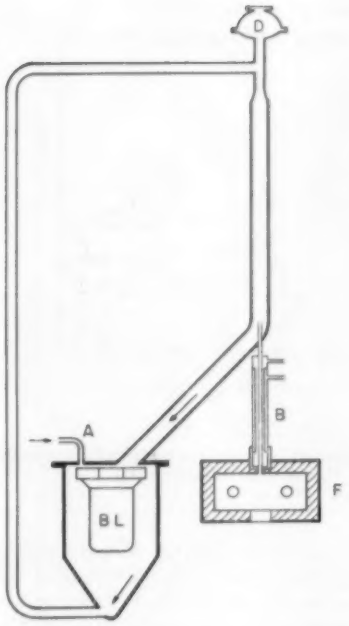

A—Air inlet
B—Burner tube
BL—Blower
D—Audio driver unit
F—Furnace

Fig. 1—Schematic diagram of test apparatus where small regulated quantities of coal were burned.

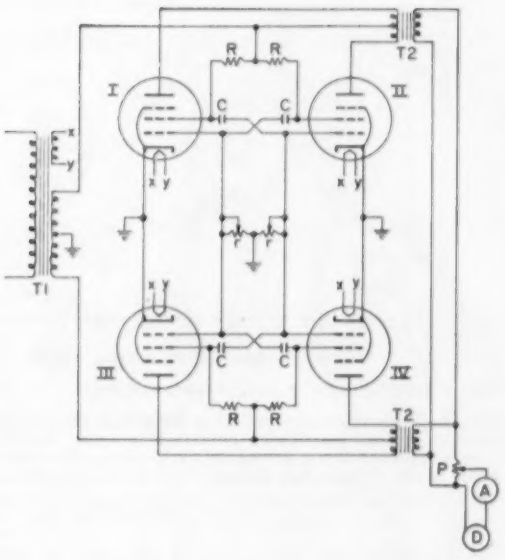

Fig. 2—Diagram of oscillator which supplied power to a driver unit that set up enough sonic energy in test furnace to prevent coal loss from adhesion to the tube walls.

*Influence of Physical Factors in Igniting Pulverized Coal**

By BIMALENDU GHOSH and A. A. ORNING
Carnegie Institute of Technology, Pittsburgh, Pa.

The ignition process for pulverized coal involves heat transfer by radiation and heat loss by conduction into the surrounding atmosphere. Anything that changes the rates of these transfers and losses changes the rate of flame propagation. This study investigates the influence of the different factors and also such burner design factors as coal fineness, fuel distribution, aerodynamic patterns

The design of pulverized coal burners has developed largely as an industrial art. Coal characteristics, fineness of grinding, distribution of coal in the air stream, heat loss from the flame, and the aerodynamic pattern are factors that influence ignition and flame stability in pulverized coal burners. The interactions of these factors, and even the manner in which they individually influence the flame, are not fully understood. This arises in part because of opposing influences upon energy release in the flame and upon energy transfer processes that are responsible for ignition of the coal as it enters the flame.

The purpose of the investigation was to study the influence of the different factors upon the ignition process independent of the influence of the same factors upon the resulting flame. For this purpose small flames were produced in an electrically heated furnace, so that most of the heat needed for ignition came from the furnace at an independently controlled temperature rather than from the flame.

Experimental

The apparatus used, Fig. 1, consisted of an electrically heated furnace, F, and a circulatory system for suspending coal in air and feeding it to the furnace. The furnace was made of refractory insulating brick, Armstrong A-26, set in a tight steel case with an open bottom. The furnace cavity was 4 by 4 by 1.5 in. high. Heat was supplied by two 0.5-in. Globars placed horizontally on 2.5-in. centers in the mid-plane of the furnace cavity. A thermocouple was placed with its junction at the midpoint between the Globars, 0.75 in. from the ceiling of the furnace cavity, and 1.0 in. from the axis of the coal feed tube. The couple was made of 16-gage Chromel and Alumel wires with an exposed junction extended 0.125 in. from its supporting tube. The burner tube was a stainless steel tube 12 in. long and 0.120 in. in inside diameter. The tip of the tube extended 0.5 in. beyond the end of a water-cooled jacket and, in the operating position, the

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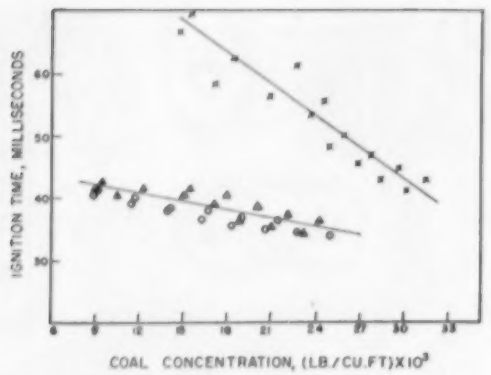
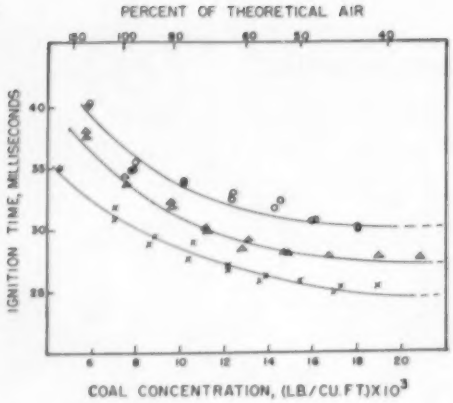


Input to driver unit: 0 1 watt, Δ7 watts, × 18 watts

Fig. 3—Sonic energy supplied at 480 cycles per second to reduce coal losses initially retarded ignition but lowering power input to driver solved this difficulty. Coal was minus 200 mesh, Pittsburgh Seam, 100 C furnace temperature.



Furnace temperature: 0 900 C, Δ1000 C, × 1100 C

Fig. 4—Ignition time against coal concentration for a minus 200 mesh Illinois No. 6 Seam coal.

tip was flush with the ceiling of the furnace cavity. A peep-hole in the front wall of the furnace was used for observing the flame. Vertical displacement of the flame could be estimated within 0.05 in. by sighting against the thermocouple tip.

The circulatory system was composed of a fan housing six in. in diameter and a circuit of 1.25- and 2.0-in. streamline tubing. A vacuum sweeper fan and motor were totally enclosed. The inlet end of the burner tube was placed on the axis of the 2.0-in. tube, seven pipe diameters below a 1.25- to 2.0-in. coupling. The circulatory system was air-tight, so that air flow through the burner tube, B, could be metered at the air inlet, A. Coal was added batchwise. Coal flow through the burner was determined gravimetrically by lifting the feed system and burner tube from the furnace and collecting the coal for one minute by aspiration into a filter.

Loss of coal in circulation, by adhesion to the tube walls, was avoided by use of sonic energy. A 30-watt University driver unit, D of Fig. 1, was used for this purpose. Power was supplied to the driver unit by an oscillator, the circuit diagram for which is shown in Fig. 2. The frequency could be varied from 500 to 5000 cycles per second and the wave form was that of a square wave within a sinusoidal, 60-cycle envelope. This wave form, with frequency variation in each 60-cycle wave, eliminated fixed nodal points where coal might adhere.

The furnace was heated to the desired temperature (±10 C) and 2 to 3 grams of pulverized coal was put into the circulatory system. A metered supply of dry air was then used to expel the coal suspension through the burner tube and into the furnace. The coal flow was periodically redetermined with an air flow rate such that the flame was kept 0.75 in. below the burner tube tip.

The ignition time was calculated as the transit time from the burner tip to the flame front, assuming that the transit velocity was equal to the average velocity within the burner tube. Ignition times were determined for coals of differing ranks, for which proximate analyses are given in Table 1. The ignition times were determined as a function of coal concentration, furnace temperature, intensity of sonic energy, fineness of grinding, and furnace atmosphere. The data obtained are presented as plots of ignition time against ratio of coal to air in Figs. 3 to 10.

Table I. Proximate Analyses of Coals Used

(As-received basis)

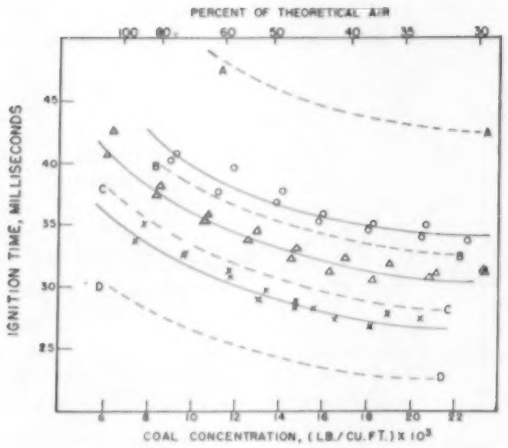
Seam	County	Moisture	Volatile Matter	Ash	Btu
Pittsburgh	Fayette, Pa.	1.6	33.6	7.5	13,910
Pocahontas No. 3	McDowell, W. Va.	0.8	15.3	5.6	14,760
Illinois No. 6	Franklin, Ill.	6.7	33.9	9.1	12,270

Discussion

For each of the coals it was found that the appearance of the flame depended upon the concentration of coal in air. At low concentrations individual particles ignited at random and contributed little to the heat transfer needed for ignition of their neighbors. With intermediate concentrations, the traces of individual particles were visible throughout the flame, but burning particles were close enough to assist in ignition of their neighbors. At higher concentrations, a continuous flame front, probably of burning volatile matter, assured immediate ignition of particles entering the flame front. Another limiting condition was found at still higher concentrations, where recirculation filled the furnace cavity with flame so that the flame front could no longer be observed. The transitions were too gradual for precise estimation of critical concentrations. The curves of ignition time vs. coal concentration, Figs. 3 to 10, cover the approximate range where well-defined flame fronts were observed.

Various uncertainties entered into estimation of ignition times. The jet of air and coal flowed down from the cooled burner tube through the hot atmosphere in the furnace. Acceleration, due to differences in density, was opposed by drag between the jet and the atmosphere of the furnace. The observed flame size indicated little expansion of the jet or mixing with the surroundings. It was, therefore, assumed that the average velocity between the tip of the tube and the flame front was equal to the average velocity within the feed tube. Ignition times, calculated on this basis, may be subject to absolute error approaching a factor of 2, but the relative values are probably good within a few per cent.

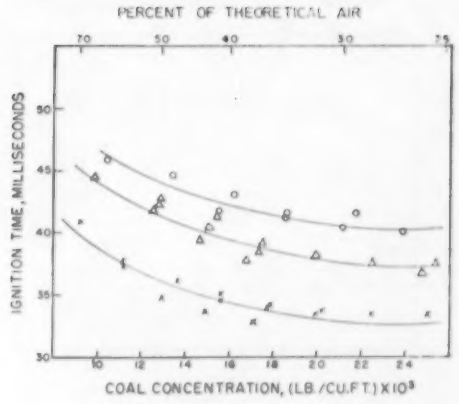
Initial studies showed a retarding effect of sonic energy on ignition process. As shown in Fig. 3, ignition of



Furnace temperature: 0 900 C, Δ1000 C, × 1100 C

Dashed curves calculated relative to 1000 C curve, AA and DD on basis of heat transfer from furnace only. BB and CC on basis of heat transfer from furnace and flame.

Fig. 5—Ignition time against coal concentration for a minus 200 Pittsburgh Seam coal.



Furnace temperature: 0 900 C, Δ1000 C, × 1100 C

Fig. 6—Ignition time against coal concentration for a minus 200 mesh Pocahontas No. 3 Seam coal.

−200-mesh Pittsburgh Seam coal was retarded when power input to the driver unit was 18 watts at 480 cycles per second, while experiments at 7-watt input showed slight retardation as compared with experiments at 1-watt input. Similar experiments at 1200 and 3000 cycles per second showed no effect. Attenuation of sonic energy in a channel decreases with decreasing frequency, so that, with the low frequency and higher power levels, there was sufficient sonic energy in the jet leaving the coal feed tube to influence the ignition process. In subsequent experiments the unit was operated with 15-watt power input at 1200 cycles per second where the sonic intensity was not a significant variable.

Coal Rank and Particle Size

Figures 4 to 6 show the influence of the rank of coal upon the ignition time. The Illinois coal, Fig. 4, was most readily ignited. Flames could be maintained with furnace temperatures as low as 900 C, and with 50 per cent excess air. The Pittsburgh Seam coal, Fig. 5, also gave a good flame at 900 C furnace temperature, but no excess air over the theoretical amount needed for complete combustion could be used. The curves for the Pocahontas coal, Fig. 6, were shaped like those for the Pittsburgh Seam coal, but the temperatures had to be increased about 100 C and the air supply had to be limited to not more than 70 per cent of theoretical.

An effect of particle size is shown in Fig. 7 for 100- to 200-mesh Pittsburgh Seam coal. The curves show significant shifts toward higher ignition times and higher coal concentrations needed for good flames, when compared with the curves in Fig. 5 for −200-mesh samples of the same coal. Similar effects were found for the Pocahontas and the Illinois coals, but the curve at 900 C was not so independent of coal concentration.

The effect of particle size was studied further by using three size fractions prepared from −200-mesh Pittsburgh Seam coal. Size distributions were determined by microscopic count and calculated to a weight basis. The coarse fraction was 50 per cent over 60- and 75 per cent over 45-micron size. The intermediate fraction was about 50 per cent over 50- and 75 per cent over 35-microns. The fine fraction was 50 per cent over 6- with none over 20- microns. Fig. 8 shows the ignition curves at 1000 C furnace temperature for each size fraction. The finest showed no greater ease of ignition that that for the intermediate size fraction. This may be due to the dependence upon particle size of the balance between the rates of heat transfer to the coal by radiation and rates of heat loss from the coal particle to surrounding air by conduction (4, 10).† It is also possible that the coal particles were not thoroughly dispersed in the air, as some evidence of clustering was found when a sample of the finest coal was collected on a microscope slide by passing it though the jet of coal in air issuing from the feed tube.

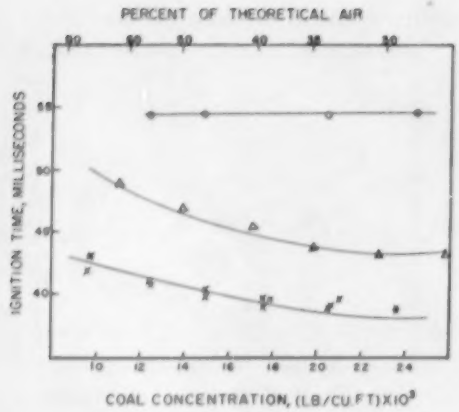
Furnace Atmosphere

The influence of furnace atmosphere upon ignition was studied by replacing the air in the furnace cavity by oxygen and by nitrogen. Fig. 9 shows resulting data on ignition time vs. coal concentration for the different furnace atmospheres with −200-mesh Pittsburgh Seam coal at 1000 C. Fig. 10 shows similar data with the same coal and furnace temperature and with air as the furnace atmosphere, but with oxygen enrichment in the primary stream of coal and air. Oxygen enrichment in the primary coal and air stream accelerated ignition, while enrichment of the furnace atmosphere had little effect except at low coal concentrations. This was interpreted as evidence for little mixing of furnace atmosphere with jet of coal and air prior to ignition. The transfer of thermal energy by mixing was correspondingly small as compared with transfer by radiation.

Test Data Interpretation

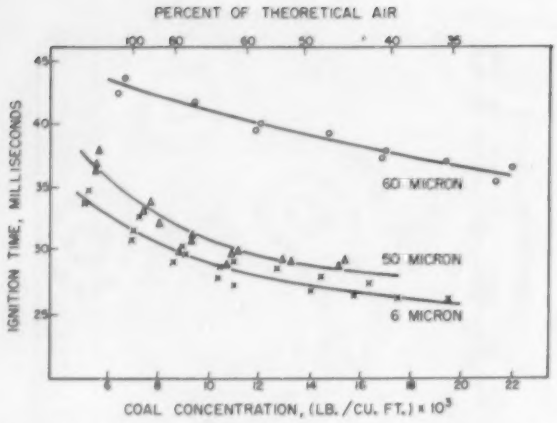
Interpretation of these experimental observations requires an analysis of the energy transfer processes involved in ignition of the coal. Nusselt (4) and Traustel (10) have made theoretical estimates of the rate of rise of temperature of coal particles prior to ignition. It was assumed that heat was transferred to the coal by ra-

† Figures in parentheses refer to similarly numbered references in the Bibliography at end of paper.



Furnace temperature: ○ 1000 C, Δ1100 C, × 1100 C

Fig. 7—Ignition time against coal concentration for a 100 to 200 mesh Pittsburgh Seam coal.



Air-elutriated fractions of Pittsburgh Seam coal, 1000 C furnace temperature, mean particle size as indicated.

Fig. 8—Ignition time against coal concentration.

diation and lost from coal to the immediately surrounding atmosphere by conduction. The relations between time and temperature are simple in two stages of the process (5, 6): first, immediately after the coal suspended in cool air enters the heated space, and again after the two heat-transfer processes have reached a quasi-equilibrium. If the coal and air enter at the same temperature, t_0, at zero time, and are exposed to radiation from all directions at the absolute temperature, T_r, the temperature of a coal particle, t, will rise at first according to the relation.

$$t = t_0 + \frac{6\sigma T_r^4}{c\rho d}\,\theta \qquad (1)$$

where c is the heat capacity, ρ is the density, d is the diameter of the coal particle, θ is the time, and σ is the radiation constant. As the particle temperature rises, heat is lost to the surrounding atmosphere and the rate of rise falls off. The modes of heat transfer reach a quasi equilibrium after a period of time, θ_e, given by the relation

$$\theta_e = \frac{c\rho d^2}{4k}\,\frac{N}{N+1} \qquad (2)$$

where k is the thermal conductivity of the atmosphere and N is the ratio of heat capacities of the associated quantities of atmosphere and coal. Thereafter the particle temperature continues to rise according to the approximate relation

$$t = t_0 + \sigma T_r^4 \left\{ \frac{N^2 d}{2(N+1)^2 k} + \frac{6\theta}{(N+1)c\rho d} \right\} \qquad (3)$$

Nusselt's estimate differed from that of Traustel in that a limited amount of excess air was not recognized. Under these conditions, $N = \infty$ and the last relation becomes

$$t = t_0 + \frac{\sigma d}{2k}\,T_r^4 \qquad (4)$$

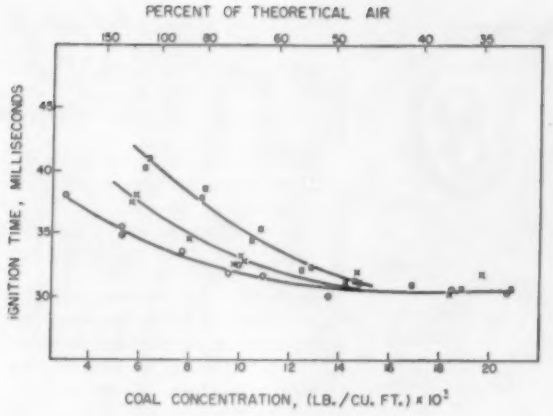
This analysis shows that the rate of rise of temperature is lower if the thermal conductivity of the atmosphere is increased. It was found experimentally that ignition was retarded when sonic vibrations increased the rate of thermal conduction into air surrounding the coal.

If Nusselt's assumptions were correct, the time required for ignition should be inversely proportional to the fourth power of the absolute temperature of the source of radiation responsible for ignition. This hypothesis was tested for the data of Fig. 5. Assuming the effective radiant temperature to be that indicated by the furnace thermocouple, and basing the proportionality on the 1000 C curve, curves for 900 and 1100 C were found by calculation to be as indicated by the dashed curves AA and DD, respectively. If it is assumed that the coal received radiant energy through half the total solid angle from the furnace and through the other half from the flame at 1500 C, these curves would fall in the position of curves BB and CC. This shows that the desired condition of having the walls of the furnace supply all the heat needed for ignition was not achieved. A substantial part of the heat transfer for ignition came from the flame. Radiation from the furnace, nevertheless, was important. Below a critical temperature, which could be determined approximately for each coal, individual particles ignited at random without a definite flame front. The curves of ignition time vs. coal concentration depended in part upon furnace temperature and in part upon a flame temperature that must have been relatively constant with a changing furnace.

The rate of heat transfer from the flame depends upon the solid angle from the coal particle to the flame. If a coal particle moves with constant velocity, u, along the axis toward a flame front with diameter, a, the total heat, q, transferred to the particle as it moves from an infinite distance to the flame front is given by the relation.

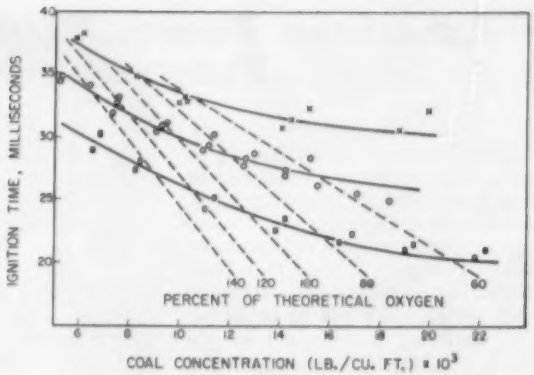
$$q = c(a/u) \qquad (5)$$

where variables independent of angle factors have been included in the constant of proportionality, c. This expression is valid within the range in which the particle temperature is low as compared with the temperature of the radiant source so that back-radiation can be neglected. The total heat transfer to the particle remains constant provided the flame size is increased in proportion to the approach velocity. As the portion of the heat



0 Oxygen, × Air, □ Nitrogen

Fig. 9—Ignition time in various furnace atmospheres, minus 200 mesh Pittsburgh Seam coal, 100 C furnace temperature.



0 30% oxygen, × Air, □ 40% oxygen

Fig. 10—Effect of oxygen enrichment in coal stream on ignition time, minus 200 mesh Pittsburgh Seam coal, 1000 C furnace temperature.

transferred by conduction from the particle to the surrounding air, and hence not available for ignition, is dependent only on local conditions and not on the flame size. Equation 5 establishes a similitude.

In the present work the flame was about $^1/_8$-inch in diameter and the approach velocity was on the order of 2 feet per second. On the basis of Equation 5, this would correspond to a velocity of 96 feet per second for a flame 6 inches in diameter. With possibly half the heat supplied by the furnace rather than by the small flame, the velocity for the 6-in. flame would be on the order of 50 feet per second. This estimate is in accord with industrial practice, but there are no published data that permit a sound comparison. A set of curves showing flame velocity as a function of the ratio of coal to air and the proximate analysis of the coal was prepared by DeGrey (2) and has been reproduced (1,3) at times with transformed coordinates. The curves were apparently based on experience with rock dusting as a means for controlling coal dust explosions in mines and upon experiments by Taffanel and associates (7–9) with coal dust flames in a refractory-lined conical tube. The experimental data were not sufficient to establish quantitative relations with proximate analyses. Nevertheless, DeGrey presented curves for coals of various volatile matter and ash contents. The curves showed maximum flame velocities at dispersions ranging from about 40 to 60 cu ft of air per lb of coal. Curves from the present investigation lie entirely on the lean side of the maxima shown by DeGrey. Furthermore, they do not indicate the high ratio of flame velocities, nearly 3 to 1, for a coal of 30 per cent compared with 15 per cent volatile matter content, that was shown in the earlier curves.

The strong influence of volatile matter content in the earlier estimates of flame velocities was probably based upon experience with explosions in mine galleries, where concentration of energy in the moving flame front depends more upon rapid combustion of volatile matter than upon slower and probably incomplete combustion of fixed carbon. The present investigation indicates that a higher furnace temperature is needed to establish a flame with the coal of lower volatile matter content, but that the flame velocity is not so markedly dependent upon volatile matter content. Limitation of primary air is a commonly practiced means for getting good ignition with coals of lower volatile matter content. According to Traustel's analysis of the heat-transfer system, the improvements result, at least in part, from the reduced thermal load resulting from the restricted amount of air associated with the coal prior to the point of ignition. It may also result, as is inherently recognized in Traustel's as well as Nusselt's analyses, from an increased radiant intensity of the flame. A study of the ignition of individual particles in a pressured atmosphere (5) showed that convective heat transfer and the "time-dependent" rather than the "steady-state" form of the equations for the heat-transfer system from the coal to the surrounding atmosphere, must be considered. A hindering effect of pressure was observed which was not readily overcome by oxygen enrichment. It could be explained on the basis of the idea that, within the short time prior to ignition, the thermal or the convective wave advanced only into a limited portion of the atmosphere associated with the coal. If such a limitation exists, the limitation given by Traustel for the heat capacity of the entire amount of associated atmosphere would seem of secondary importance.

Though the analyses of Nusselt and Traustel may be questioned on theoretical grounds, the importance of the effects with which they deal has been substantiated experimentally by the above reported work.

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(10) Traustel, S., *Feuerungstech.*, 29, 1–6, 25–31, 49–60 (1941)

RECEIVED for review June 16, 1954. ACCEPTED October 12, 1954. Based on a D.Sc. thesis at the Carnegie Institute of Technology entitled "A Study of the Conditions Necessary for Producing Small Flames with Pulverized Coal" by Bimalendu Ghosh, 1951.

American Power Conference Program

THE seventeenth annual meeting of the American Power Conference will be held on March 30, 31 and April 1 at the Sherman Hotel in Chicago. A program of interest to those engaged in almost every activity relating to the generation, transmission, distribution or utilization of power will be presented. The Conference is sponsored by the Illinois Institute of Technology in cooperation with fourteen leading universities and ten national and regional societies throughout the United States.

For further information write to: R. A. Budenholzer, Director, American Power Conference, Illinois Institute of Technology, Technology Center, Chicago 16, Ill. The major portion of the preliminary program is contained in the following listing.

Wednesday, March 30, 1955, 9:00 a.m. Registration

10:00–12:00 Noon. Opening Meeting

"Where We Stand Today in the Electric Industry," by John W. Evers, President, Commonwealth Edison Company, Chicago.

"Research in the Utility Industry," by Howard P. Seelye, Manager of Engineering, Detroit Edison Company, Detroit, Mich.

12:15 p.m. American Power Conference Luncheon. Sponsored by the American Society of Mechanical Engineers.

Speaker: Harold Quinton, President, Edison Electric Institute.

2:00–3:30 p.m. Central Station Steam Generators

"The Monotube Once-Through Boiler for Conventional or Supercritical Pressures," Arthur T. Hunter, Vice President, Combustion Engineering, Inc., New York, N. Y.

"The Operation of Large Central Station Steam Generators," Gerald V. Williamson, Vice President, and John K. Bryan, Assistant to Superintendent-Production, Union Electric Company of Missouri, St. Louis, Mo.

2:00–5:00 p.m. Water Resources

"St. Lawrence Seaway," by Raymond F. Stellar, Engineer, St. Lawrence Seaway Development Corporation, Washington, D. C.

"Utilization of Saline Waters," by David Jenkins, Department of the Interior, Washington, D. C.

"Some Effects of Precipitation on Ground Water in Wisconsin," Wm. J. Drescher, District Geologist, U. S. Geological Survey, Madison, Wis.

"Use of Water for Irrigation, Navigation and Power," by R. J. Pafford, Jr., Missouri River Division, U. S. Division Engineers Office, Omaha, Nebr.

2:00–5:00 p.m. Industrial Steam and Power

"When Should Industry Generate Electricity?" by M. L. Jones, Principal Power Engineer, E. I. du Pont de Nemours & Company, Inc., Wilmington, Del.

"Let's Take the Guesswork Out of Industrial Power Costs," by F. B. Banton, Consulting Engineer, Downers Grove, Ill.

"Fast Starting of 150,000 Pound Per Hour Industrial Boilers," by C. E. Morrow, Factory Planning Engineer and R. F. Born, Mechanical Engineer, Western Electric Company, Chicago.

"How to Reduce Spreader Stoker Fly Ash," by Cole H. Morrow, Chief Plant Engineer, J. I. Case Company, Racine, Wis.

2:00–5:00 p.m. Electrical Industrial Session

"Series Capacitors Eliminate Voltage Fluctuations in Industrial Plants," by T. H. McGreer, Sargent and Lundy, Engineers, Chicago.

"Dry Type Versus Liquid Cooled Transformers for Industrial Systems," by W. M. Terry, Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

3:30–5:00 p.m. Research in Steam Generators

"Research in the Field of Steam Generators," by Leslie S. Wilcoxson, Vice President, The Babcock and Wilcox Company, New York, N. Y. and W. H. Armacost, Vice President, Combustion Engineering, Inc., New York, N. Y.

7:30–10:00 p.m. Development of Atomic Energy for Power Purpose.

Panel Members:

Philip Sporn, President, American Gas and Electric Company, representing a Nuclear Power Study Group.

Walker L. Cisler, President, Detroit Edison Company, representing the Atomic Power Development Associates.

William Webster, Executive Vice President, New England Electric System, Representing The Yankee Atomic Electric Co.

James F. Fairman, Vice President in Charge of Engineering, Consolidated Edison Co. of New York, N. Y.

Thursday, March 31, 1955 9:00 a.m.–12:00 Noon. Research in Steam Turbines

"Advances in Large Steam Turbine Research and Development," by H. D. Emmert, Assistant Chief Engineer, Steam Turbine Section, Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

"The Laboratory as an Engineering Tool in Steam Turbine Research and Development," by F. K. Fischer, Manager, Development Engineering, Steam Division, Westinghouse Electric Company, Philadelphia, Pa.

"Research and Development in the Field of Turbine-Generator Prime Movers in the General Electric Company," by Glenn B. Warren, Vice President and General Manager, General Electric Company, Schenectady, N. Y.

9:00 a.m.–12:00 Noon. Water Technology I—Symposium on Operation of Demineralizers for Treating Makeup for Steam Power Plants

"Demineralization of Makeup for Public Utility Plants," by J. A. Wallace, Assistant General Production Manager and L. W. White, Chemical Engineer, Iowa Electric Light and Power Company, Cedar Rapids, Iowa.

"Demineralization of Boiler Feed Makeup for Paper Mills," by T. J. Judge, Power Coordinator and Division Power Engineer and C. L. Davis, Jr., Chemical Engineer, International Paper Company, Mobile, Ala.

"Treatment of Makeup Water With a Four-Bed Demineralizing Plant," by W. M. Mayer, Results Engineer, Central Power and Light Company, Corpus Christi, Tex.

"Treatment of Makeup Water with Automatic Mixed-Bed Demineralizer for the Pennsylvania Electric Company," by J. H. Brendlen, Engineering Department, Gilbert Associates, Inc. Reading, Pa., V. J. Calise, Vice President, Graver Water Conditioning Company, New York, N. Y., and S. F. Borgel, Mechanical Engineer, Pennsylvania Electric Company, Johnstown, Pa.

9:00 a.m.–12:00 Noon. Industrial Applications

"The Impact of Air Conditioning on the Electric Utility Industry," by Fischer Black, Editor and Publisher, *Electrical World*, New York, N. Y.

"Principles of Automatic Controls," by John Diebold, Management Consultant, John Diebold and Associates, Inc. and Editor and Associate Publisher, *Automatic Controls Magazine*, New York, N. Y.

"The Importance of Complete Cooperation of Heavy Equipment Manufacturers with Utilities," by O. V. Talley, Director of Industrial Sales, Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

10:30 a.m.–12:00 noon Electrical Equipment

"Use of Magnetic Amplifiers in Exci-

tation Control," by T. J. Bliss, Industry Engineer, Westinghouse Electric Corporation, East Pittsburgh, Pa.

"The Philosophy of Modern Generator Voltage Regulators," by H. W. Gayek, A. S. Rubinstein, and M. Temoshok, General Electric Company, Schenectady, N. Y.

"New Excitation System Without Commutators," by W. L. Ringland and H. W. Cory, Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

12:15 p.m. American Power Conference Luncheon Sponsored by the American Institute of Electrical Engineers.

Speaker: C. H. Linder, Vice President, General Electric Company, Schenectady, N. Y.

2:00–5:00 p.m. Central Station Power Plants

"Central Station Design for Overall Economy," by Paul Gourdon, Chief Mechanical Engineer, Ebasco Services, Inc., New York, N. Y.

"Dynamic Behavior of Power Plant Stacks Under Wind Loading," by Clem G. Merriman, Civil Engineer and Sacid Ozker, Assistant Division Supervisor, Mechanics Division, Engineering Laboratory and Research Department, Detroit Edison Company, Detroit, Mich.

"Foundation Problems in Power Plant Design and Construction," W. S. Housel, Department of Civil Engineering, University of Michigan, Ann Arbor, Mich.

2:00–5:00 p.m. Fuels I.

"Probable Trend in Coal Freight Rates," by Ford K. Edwards, Director, Bureau of Coal Economics, National Coal Association, Washington, D. C.

"Research in Natural Gas Substitutes," by Elmore S. Pettyjohn, Vice President, Illinois Institute of Technology and Director, Institute of Gas Technology, Chicago.

"Research in the Coal Industry," by H. J. Rose, Vice President and Director of Research, Bituminous Coal Research, Inc., Pittsburgh, Pa.

"Research in the Petroleum Industry," by J. K. Roberts, General Manager, Research and Development, Standard Oil Company of Indiana, Chicago.

2:00–3:30 p.m. Developments in Small Gas Turbines

"Research and Development of an Experimental Rotary Regenerator for Automotive Gas Turbines," by W. W. Chao, Engineering Staff, Ford Motor Company, Dearborn, Mich.

"Progress in Automotive Gas Turbines," S. D. Hage, Chief Project Engineer, Gas Turbine Dept. Boeing Airplane Co., Seattle, Wash.

2:00–3:30 p.m. Electrical Distribution I

"Distribution Trends and Obsolescence," by L. M. Olmsted, Associate Editor, *Electrical World*, New York, N. Y.

"Voltage Divider Method of Capacitor Switching," by Harold C. Stone, Product Engineer, Capacitor Section, Line Material Company, Milwaukee, Wis.

3:30–5:00 p.m. Electrical Distribution II

"Distribution System to Meet Rapidly Growing Residential Loads," by H. H. Watson, Commercial Engineer, Construction Materials Division, General Electric Company, Bridgeport, Conn.

"Distribution Systems to Meet Increased Domestic Loads," by H. E. Lokay, Industry Engineer, Westinghouse Electric Corporation, East Pittsburgh, Pa.

3:30–5:00 p.m. Automatic Generating Equipment for Utilities.

"Mobile Electric Automatic Generating Equipment for Utilities," by B. H. Hefner, Chief Electrical Engineer, K. O. Bower, A. C. Engineer, and E. A. Armstrong, Consultant, Electro-Motive Division, General Motors Corporation, La Grange, Ill.

"Starting Characteristics of Isolated Large Diesel Generators with Initial A-C Load," by A. Hoffman, Westinghouse Electric Corporation, Pittsburgh, Pa.,

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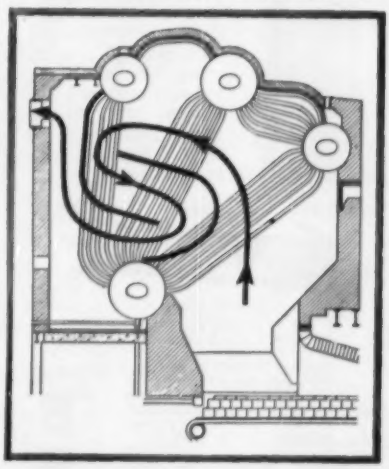

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Leo Brinson, Nordberg Manufacturing Company, Milwaukee, Wis., and R. W. Flugum, Consulting and Application Engineer, Westinghouse Electric Corp., Milwaukee, Wis.

Friday, April 1, 1955, 9:00 a.m.–12:00 Noon. Gas Turbines for Power Plants

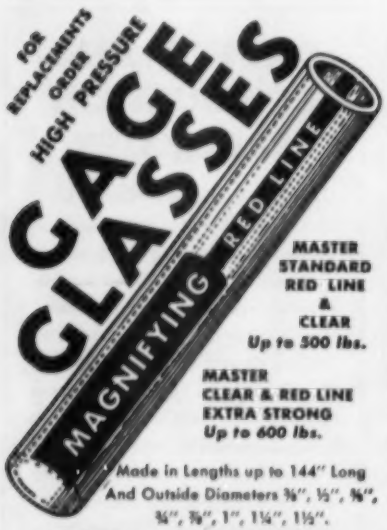
"Combined Gas Turbine-Steam Turbine Power Plant Cycles," by A. A. Hafner, Manager, Product Planning and Marketing Research, Gas Turbine Division, and W. B. Wilson, Manager, Power Generation Engineering, Industrial Engineering Section, General Electric Company, Schenectady, N. Y.

"5000 Horsepower Dual Shaft Gas Turbine Power Plant," J. O. Stephens and D. F. Bruce, Gas Turbine Engineering, Westinghouse Electric Corp., Philadelphia, Pa.

"Application of Gas Turbines to Nuclear Power Plants," by Howard Grantz Manager, and B. A. Neuffer, Atomic Power Equipment Engineering Sub-Section, General Electric Company, Schenectady, N. Y.

9:00–10:30 a.m. Cooling Towers for Central Station Plants

"Cooling Towers—Their Influence on Prospective Plant Sites," by R. W. Gausmann, Power Production Engineer Indianapolis Power and Light Company, Indianapolis, Ind.



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"Cooling Towers for the Power Industry," by Frank J. Lockhart, Manager of Product Development and Jack M. Whitesell, Chief Products Development Engineer, and A. C. Catland, Jr., Senior Contract Administration Engineer, The Fluor Corporation, Ltd., Los Angeles, Calif.

9:00–10:30 a.m. Water Technology II

"Centralized Control of Boiler and Feedwater Chemical Treatment of the Valley Steam Plant," by Russell C. Alexander, Superintendent, and Jack Korenthal, Laboratory Technician, Valley Steam Plant, Department of Water and Power, Los Angeles, Calif.

"Application and Treatment of Water for Heat Pump Systems," by C. W. Millsom, Vice President, Acme Industries, Jackson, Mich.

9:00–10:30 a.m. Electrical System Planning I

"Overall Planning of Systems for the Long Range Future," by H. L. Melvin, Chief Consulting Engineer, Ebasco Services, Inc., New York, N. Y.

"Location of Future Generation—Economic Analysis," by G. P. Wilson, Manager of Power Production, Illinois Power Company, Decatur, Ill.

10:30 a.m.–12:00 Noon. Electrical System Planning II

"Area Studies and the Prediction of Load Growth," by E. L. Kanouse, Assistant Engineer of Construction and Design, and J. W. Reinhard, Electrical Engineering Associate, Department of Water and Power, Los Angeles, Calif.

"Possibilities for Greater Regional Coordination of Power Systems in the United States" by Francis L. Adams, Chief, Bureau of Power, Federal Power Commission, Washington, D. C.

10:30 a.m.–12:00 Noon. Water Technology III

"Conditions Where Sticking of High Pressure Steam Valves May Occur," by C. L. Mead, Design Engineer, General Electric Company, Schenectady, N. Y.

"Blue Blush Characteristics," by F. G. Straub, Research Professor of Chemical Engineering, University of Illinois, Urbana, Ill.

10:30 a.m.–12:00 Noon. Industrial Steam Generators

"Air Preheater for Small Power Plants," by W. E. Hammond, Chief Engineer, and C. L. Brown, Technical Consultant, Air Preheater Corporation Wellsville, N. Y.

"Standard Steam Generators—Influence of Design Changes on Cost," by D. Cassino, Design Engineer, Foster Wheeler Corporation, New York, N. Y.

12:15 p.m. American Power Conference Luncheon Sponsored by the

Western Society of Engineers.

Speaker: Farrington Daniels, Chairman, Department of Chemistry, University of Wisconsin, Madison, Wis.

Subject: Solar Energy

2:00–5:00 p.m. Progress in Nuclear Technology for Power Generation

"Reactor Research and Development," by W. Kenneth Davis, Deputy Director, Division of Reactor Development, Atomic Energy Commission, Washington, D. C.

"Sodium Graphite Reactor Power Plant," by Chauncey Starr, North American Aviation, Downey, Calif.

"The Nuclear Plant as a Part of Future Power Systems," B. R. Prentice, Manager, Atomic Power Studies and A. G. Mellor, Application Engineer, General Electric Co., Schenectady N. Y.

"Power From Atomic Energy," by John W. Landis, Sales Manager, Atomic Energy Division, The Babcock and Wilcox Company, New York, N. Y.

2:00–3:30 p.m. Water Technology IV Sponsored by Joint Research Committee on Boiler Feedwater Studies.

"Filming Amines—Use and Misuse in Power Plant Water-Steam Cycles," by J. F. Wilkes, Director of Research and Product Development, W. L. Denman, Directing Chemist, Dearborn Chemical Company, Chicago and M. F. Obrecht, Department of Chemical Engineering and Water Treatment Consultant, Michigan State College, East Lansing, Mich.

"Experience with Filming Amines for Improving Heat Transfer," by J. G. Weidman, Engineering Department, W. H. & L. D. Betz, Philadelphia, Pa.

2:00–5:00 p.m. Computers and Network Analyzers

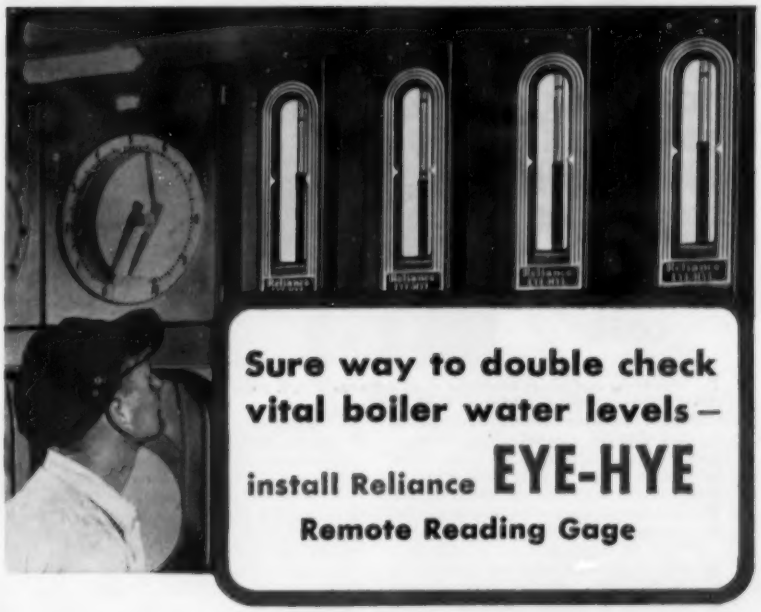
"Application and Design of Penalty Factor Computer," by C. A. Imburgia and G. W. Stagg, American Gas and Electric Service Corporation, New York, N. Y., and K. R. Geiser and L. K. Kirchmayer, General Electric Company, Schenectady, N. Y.

"Operating Experience with the World's First Incremental Cost Computer for Delivered Power," by E. D. Early, Southern Services, Inc., Birmingham, Ala.

"Analyzer Features Made Possible by Zero-Loss Reactors," by E. W. Atherton, I-T-E Circuit Breaker Company, Philadelphia, Pa.

"Operation and Design Consideration of a 60-Cycle Network Analyzer," by S. N. Witts, Northern States Power Company, Minneapolis, Minn., and R. E. Koll, System Analyzer Corporation, Nokomis, Ill.

"Summary of Network Analyzers in Operation in the United States and Canada," by Eric T. B. Gross, Illinois Institute of Technology, Chicago.



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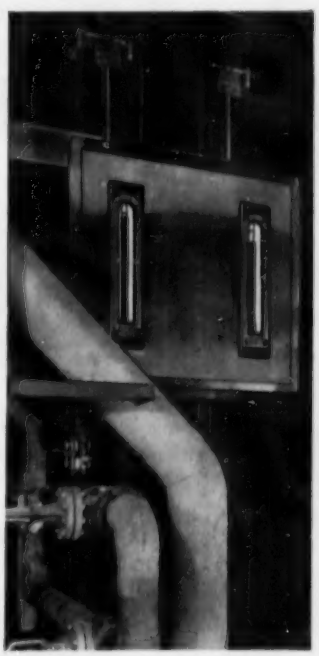

How one user checks water levels in surge tank and feed water heater with long type EYE-HYEs. (Face plate can be calibrated at factory.)

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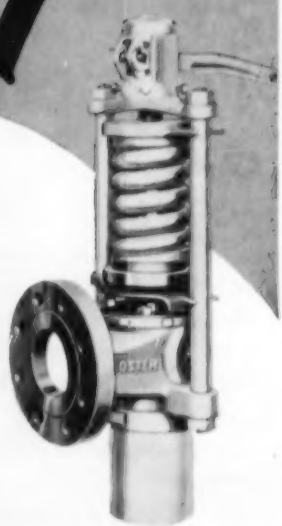

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Electrical Engineers Convene In New York

BETTER than 4000 engineers from all over the country attended the Winter General Meeting of the American Institute of Electrical Engineers in New York City, January 31–February 4, 1955.

M. D. Hooven, Public Service Electric and Gas Co. of N. J., was nominated as the 1955–1956 president according to the announcement by N. S. Hibshman, Institute secretary. Vice presidents nominated were: Cullen T. Pearce, Westinghouse Electric Corps. William J. Miller, University of Alabama, Evan R. Jones, Mountain State Telephone and Telegraph Co., Bradley Cozzens, Water and Power Dept., City of Los Angeles, and Bristow G. Ballard, National Research Council of Canada.

Directors nominated were Julian D. Tebo, Bell Telephone Laboratories, Paul G. Wallace, Texas Power & Light Co. and John C. Woods, Commonwealth Edison Co. Walter J. Barrett, N. J. Bell Telephone Co., was renominated as treasurer for one year.

John Fritz Medal

A. C. Monteith, vice president, Westinghouse Electric Corp., and president of the AIEE, presented the 1954 John Fritz Medal to H. A. Winne, retired vice president of General Electric Co., "for services to his country in war and peace through his distinguished leadership in the electrical industry."

Chester Lang, G. E. vice president, reviewed Mr. Winne's career of nearly 45 years as a General Electric engineer and executive. During the war Mr. Winne played a prominent part in the development of atomic energy and after the war he was chairman of the G. E. three-man Nuclear Energy Projects Committee. In addition Mr. Winne has had thirteen patents to his credit.

In his reply at the presentation Mr. Winne said in part: "First, industry, government and educational institutions must try to utilize the full ability of every technically trained person, so that he develops the maximum output of which he is capable.... Second, and perhaps more important, we must develop more, and more competent teachers. We must attract able people to the teaching profession by making it more rewarding than it is today, particularly financially, and especially in the secondary and elementary schools.

Varied Program

Scientific and technical advances are creating a great need for a new type of engineer, according to the paper by Gordon S. Brown, head of the Electrical Engineering Department of Massachusetts Institute of Technology entitled: "Educating Electrical Engi-

neers to Exploit Science." As a result MIT has embarked on a new engineering program designed to equip students with the technical substance and professional vision that will permit sustained creative development, backed up by a deep sense of their social responsibility.

Professor Brown pointed out that college curriculums have neglected the field of power engineering, or conversion of mechanical and other forms of energy into electricity, and have allowed their apparatus in this field to become old, and in comparison with electronics and communications, ponderous, inflexible, and lacking in scope for the cultivation of student resourcefulness. Complex processes of energy conversion, control, and utilization that demand engineering skill of the highest order are becoming numerous.

We already have nuclear fission, solid-state energy converters such as the solar battery, supersonic aviation, high-temperature metallurgy, chemical synthesis, and many others. These coupled with major advances in magnetic, dielectric, and semiconductor materials which wholly permit new solid-state devices, will expand the field and create a great need for a new type of engineer.

But as power engineering has been presented to students, it has failed to attract sufficient numbers with sufficiently high intellectual ability and creative breadth to meet the needs. On nearly every campus power engineering has become the poor relation, both financially and intellectually, by contrast with the fields that support the mission to process and transmit information. A sharp and decisive reversal of this situation is needed.

New electronic developments of great promise for the future—a music synthesizer, a cooling system, a light amplifier and a magnetic tape recorder for television and motion pictures were described by Brig. General David Sarnoff, of the Radio Corporation of America, in his talk, "New Developments in Electronics."

The Music Synthesizer, is an electronic system capable of generating any tone produced by the human voice or any musical instrument, as well as any musical tone which is beyond the capabilities of a voice or conventional musical instrument.

This electronic instrument also offers new opportunities for production of phonograph records, since it can produce any kind of sound that can be imagined. Further, with this new system, old recordings can be rejuvenated into new phonograph records free from distortion and noise.

An electronic air conditioner, designed without any moving parts, motors or compressors, is on the way and encouraging progress is being made in RCA Laboratories. In effect, it is an all-electronic cooling system believed to be the first refrigerator to achieve practical storage and freezing temperatures entirely by electronic means, although the principle upon which it operates was discovered by the French physicist, Jean Charles Peltier, more than 120 years ago. Peltier observed that passage of an electric current through the junction of two dissimilar materials produces a cooling or heating effect in the region of the junction, depending upon the direction of the current.

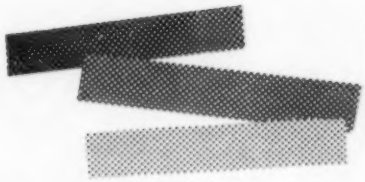
This so-called "Peltier effect" has long been a scientific curiosity chiefly because of the lack of materials capable of producing temperatures sufficiently low for practical use in cooling or refrigeration. Unlike Peltier, Lord Kelvin and others who studied this effect, the RCA scientists were able to approach the task with new knowledge provided by recent studies in solid-state physics.

In still another new field, RCA scientists and engineers have made substantial progress in the development of an electronic light amplifier. An experimental design has already given light amplification in ratios of more than 20 to 1. When that ratio reaches 100 to 1, a practical amplifier of light will be at hand, and a significant advance in the science of illumination for lighting and for television picture reproduction will have been made.

Turbine Generator

A number of papers were presented on different phases of turbine generator operation and maintenance. One, "Proposed Guide for Maintenance of Turbine Generators" by **J. W. Jones,** Philadelphia Elec. Co., was a conference paper presented to draw comments and discussion of the proposed section on maintenance by the AIEE Committee on Rotating Machinery, Synchronous Machinery Subcommittee, for inclusion in a guide they are preparing. The paper listed several general considerations on turbine generator maintenance and then offered specific points applying to particular parts and processes under their own headings.

A second Philadelphia Electric Co. author, **E. I. Gallagher,** presented a paper "Turbine Generator Operation and Maintenance Practice of Philadel-



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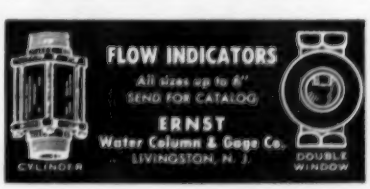

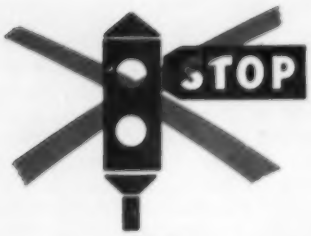

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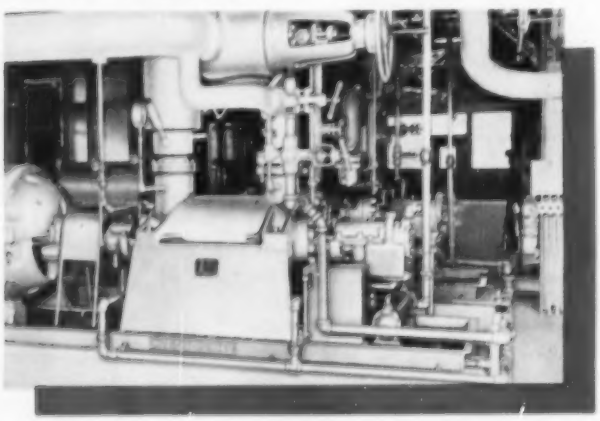

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phia Electric Co." This paper showed the practice in a typical large power system and is one of a group of papers requested by the Committee on Rotating Machinery, Synchronous Machinery Subcommittee, in connection with their work in preparing the proposed AIEE guide referred to above entitled Operation and Maintenance of Turbine Generators.

The author's company system includes seven steam and one hydro generating stations with a total installed capacity of 2286-mw. The company is a member of the Pa.-N. J. Interconnection which operates installed capacity of 7756-mw. The company's generating capacity by steam is distributed among thirty-two units, ranging in size from 14-mw to 182-mw. Seven of these generators exceed 100-mw capacity. Generator voltages are all at 13,800 volts except the latest addition which is 20,000 volts.

The 1953 system peak was 1873-mw with 978-mvar. There are five synchronous condensers of 30-mvar each and approximately 50-mvar of fixed static condensers on the system. An additional 75-mvar is available on the 60-cycle motors of the frequency converters which supply the railway and streetcar load. The system power factor varies from 84 per cent at heavy load periods to 91 per cent during light load periods.

The units are loaded on an incremental cost basis. This means that only those units required for generation and local area or interconnection reserve are in service. All other units are taken off the line as load conditions permit. As a result about nine machines go on the line every morning. Some units may go on twice a day for short periods over the peaks. Others have a twenty-four hour demand and come off only when necessary. One unit operated continuously for over six months and came off at the manufacturer's recommendation to test the overspeed trip mechanism.

Reactive load is adjusted on the generators, converters, and synchronous condensers to attain the best conditions. Generators are never operated with leading p.f., as far as possible the reactive is carried in the area where it is required. This is limited by the nameplate rating for field or armature current, or maximum permissible coil temperature. None of these values is ever exceeded. Normally, the maximum loading is determined by the field or armature current. Maximum coil temperatures run up to 90 C on some generators at full load. However, the maximum on most generators is about 70 C.

The system is operated on 13-kv

and 33-kv bus voltage schedules for the various locations. The generators carry the required voltage to maintain the scheduled bus voltage and the necessary reactive. In accomplishing this the generator terminal voltage may be 5 per cent above the rated voltage for the machine.

Voltage regulators are used on most all the generators. Rheostatic and vibrating type regulators control voltage on the older generators while static type with fast response control voltage on the newer large generators. They have been very satisfactory. The regulators are cleaned and inspected on a routine schedule. The larger units are provided with a minimum excitation limit to prevent instability.

The fundamental generator protection is a current differential relay on the windings. Some of the generators have phase and ground overcurrent relays for back-up protection. Several units have reverse power relays which are for turbine protection primarily. On loss of field the procedure is to trip the unit immediately. Loss of field relays are being installed on the larger units.

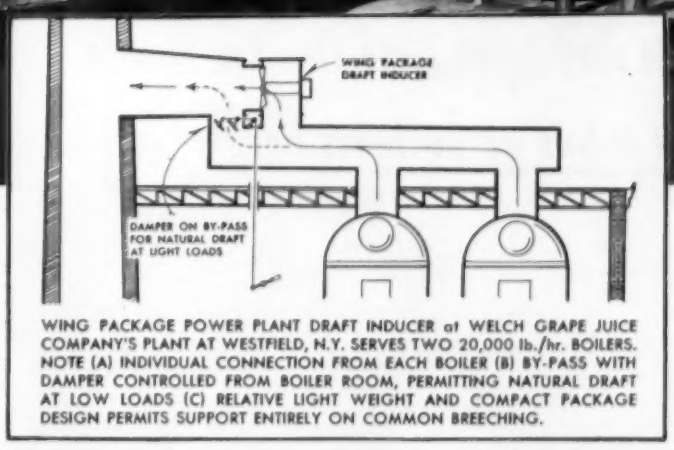
Condensing units from 60-mw to 182-mw capacity are taken off nightly for as short a time as four hours. These units are returned to service in twenty minutes after shutdown of less than eight hours. The limiting factor in the rate of loading the unit is the turbine conditions. The generator is not considered. Generally units going on the line are loaded at a rate of not more than two per cent per minute of the full load rating. After being on the line and operating conditions are normal, larger rates of change are made. Preheating of the field in starting has been used for three large units on recommendation of the manufacturer.

The cooling system of air-cooled generators are operated to maintain substantially constant coil temperatures. Cooling water is adjusted manually to accomplish this. Several air cooled systems have electric heaters in the air ducts to maintain a temperature high enough to prevent condensation while the unit is off the line. This also helps constant coil temperature.

Hydrogen cooled generators maintain a constant ambient. This is done by holding the cold gas temperature constant, usually at about 35 C. Control is by manual adjustment of the cooling water.

The hydrogen pressure carried on any particular unit depends upon the load dispatchers requirements for reactive. The generating station is informed of the estimated kva that will be required from the unit and

The WING Package DRAFT INDUCER



WING PACKAGE POWER PLANT DRAFT INDUCER at WELCH GRAPE JUICE COMPANY'S PLANT AT WESTFIELD, N.Y. SERVES TWO 20,000 lb./hr. BOILERS. NOTE (A) INDIVIDUAL CONNECTION FROM EACH BOILER (B) BY-PASS WITH DAMPER CONTROLLED FROM BOILER ROOM, PERMITTING NATURAL DRAFT AT LOW LOADS (C) RELATIVE LIGHT WEIGHT AND COMPACT PACKAGE DESIGN PERMITS SUPPORT ENTIRELY ON COMMON BREECHING.

The WING Package DRAFT INDUCER is unique in that the motor (or turbine) and fan is designed as one complete removable unit, making installation easier and being easily removed, facilitates inspection and maintenance. Other advantages are:

1. Big savings in space requirements
2. Permits fewer and lighter structural supports
3. Eliminates field line-up problems
4. Eliminates water cooling
5. Only two support bearings
6. Wide flexibility in gas outlets
7. Saves on investment and maintenance
8. Low load ratings on natural draft because of ample free gas travel area

Write for complete details

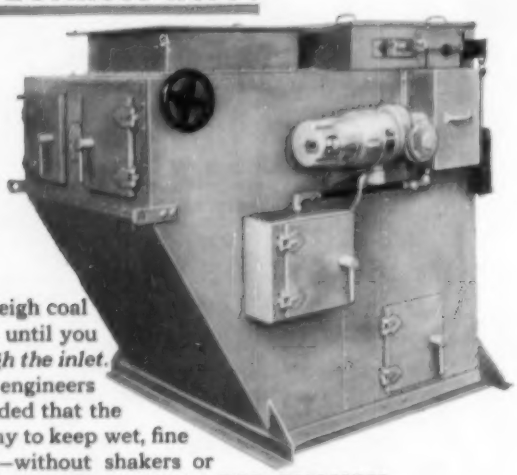
Wing

L. J. Wing Mfg. Co.
54 Vreeland Mills Road
Linden, New Jersey

the hourglass shape...

...it may have been fine for Fannie,

but it has no business here!



You can't weigh coal in *any* scale until you *get it through the inlet.* Richardson engineers have concluded that the only sure way to keep wet, fine coal flowing—without shakers or vibrators—is to make that inlet BIG ENOUGH. So they opened up the "wasp waist" to a full 24″ x 24″, and around it they built the best coal scale it was possible to develop from fifty years' experience, the Richardson H-39.

If you're interested in maximum coal scale *efficiency* at wholly reasonable cost, specify a 24″ x 24″ minimum, and *know* that your coal will flow. That is the starting point from which the H-39 is soundly engineered in every feature, every detail. It's built as a coal scale *should* be, from the inside out, with a full 4 square feet of inlet. Get all the details, mechanical specifications, and drawings in Bulletin 0352.

Richardson

MATERIALS HANDLING BY WEIGHT SINCE 1902

RICHARDSON SCALE COMPANY

Clifton, New Jersey

Atlanta • Boston • Buffalo • Chicago
Detroit • Houston • Memphis • Minneapolis
New York • Omaha • Philadelphia • Pittsburgh • San Francisco • Wichita • Montreal
Toronto • San Juan • Havana • Mexico City

sufficient hydrogen pressure is maintained to carry the estimated load on the generator. This procedure reduces hydrogen consumption and leakage. Normally the maximum kva required from a generator will not vary much from day to day on units capable of operating at 15 psig or higher hydrogen pressure. These, being the newer and more efficient units, will carry full load daily. In the event more reactive is required, the hydrogen pressure can be quickly increased.

At the present there has been no occasion to operate above 15 psig hydrogen pressure except for generator capability tests. At 15 psig hydrogen leakage may amount to 250 cu ft per day on large generators. Hydrogen consumption is watched closely and any increase is noticed immediately. Leakage is checked with an explosimeter type detector.

Generator maintenance may be divided into electrical and mechanical phases. The maintenance section inspects for physical damage to the generators. They look for loose wedges, broken supports, core movement, coil distortion, tape separation, loose retainer rings, and any other visible effect. Collector rings are never ground or polished unless they are giving trouble. Nothing is done to them on the basis of appearance. Generator fields on closed cooling systems are not removed at every inspection period.

The field winding resistance is carefully measured during complete inspections. Variations from the original value are carefully noted and any appreciable change is investigated. This has shown up loose connections in the field leads of several machines.

The station forces megger the armature and field at 500 v every month or when possible. No routine hi-voltage tests are made. The only time this is done is when there is suspected damage or repairs or replacements in the electrical circuit. At the present several generators have difficulty with tape separation and they are given a hi-pot annually. Absorption tests are made for ten minutes during each complete inspection period, in general using for the field 500 v and for the armature 1000 and 10,000 volts.

Since internal inspections after the first year have shown relatively little trouble, the period between subsequent complete inspections is being extended to as much as five years. No generator forced outages have been attributed to operating practices.

"Operation of Turbine-Generators During Off-Peak High Power-Factor Periods—Practices of One Utility in a Metropolitan Area" was presented

by **W. J. Roberts** and **R. L. Webb,** Consolidated Edison Co. of N. Y.

Before the beginning of World War II, the Consolidated Edison 60-cycle system operated with the load distributed mainly from the generating station buses with relatively low capacity, intermediate voltage, tie feeders inter-connecting the major stations from north to south. The largest of the several interstation ties was rated about 40-mva. Some operated at 13-kv and at 27-kv.

In general, the load power-factors of that time, measured at the generating station bus, varied from 0.83 to 0.85 during the day load and dropped to 0.78 to 0.80 during the early morning hours of off-peak load operation. These loads were carried with generator terminal power-factors varying from 0.80 minimum during the day, to 0.75 during off-peak operation. Capacitive loading consisted of the 13-kv and 27-kv distribution feeder cables plus a small amount of 4-kv distribution feeder capacitors.

Since the beginning of World War II, the 60-cycle system has experienced a peak load increase of 61 per cent with a corresponding increase of 65 per cent in generating capacity and has been equipped with a double circuit, high-voltage (138-kv) tie-feeder system between the North and South ends of the area served. In addition, one new generating station has been built to supply power into this tie-feeder network. Area substations supplied from the high-voltage circuits have been constructed to supply medium voltage distribution systems direct from the 138-kv circuits.

The new 138-kv system circuits are made of pressure-pipe type and oil-filled cable feeders. These, including the older 138-kv cables between Westchester County and the Hell Gate Generating Station, have added a total of approximately 295 capacitive megavars to the system load at normal voltage. Also, the installation of unswitched capacitors on the 4-kv distribution part of the system have added an additional 85-megavars.

CORRECTION NOTICE

In the January issue of COMBUSTION, the editorial, "Sulfur Elimination from Fuels," did not credit the Institute of Fuels as the sponsor for the Special Study Conference on Sulfur held in London last October.

200-1

FOR WANT OF A NAIL...

Something that wasn't there once cost a king his life.

For today's boiler, lack of internal protective surfacing is hardly a life or death matter. Yet consulting engineers . . . insurance underwriters . . . power plant operators increasingly specify, recommend, and purchase Apexior Number 1 for tube and drum coating. Why?

Because the yardstick of return on investment proves Apexior's unique service *now pays off at the highest rate ever* . . . for modern boiler design and operation today permit a single Apexior application to deliver maximum protection not only for a normally anticipated five years, but for one — three — sometimes even *five years more!*

And because Apexiorizing is now a one-coat procedure, former material and labor estimates are halved. Protection that can last twice as long today costs *half as much* . . . a trifling pennies-per-square-foot premium to insure full return on a major capital investment.

Like the legendary nail, boiler protective coating may seem a factor of small significance — yet it can mean the difference between acceptable performance and the best of which the modern boiler is capable. The assurance every inspection gives that tubes and drums are functioning at new-metal peak efficiency is the measure of Apexior's service in maintaining highest steam production reliability and quality — a contribution measured ultimately in profit dollars.

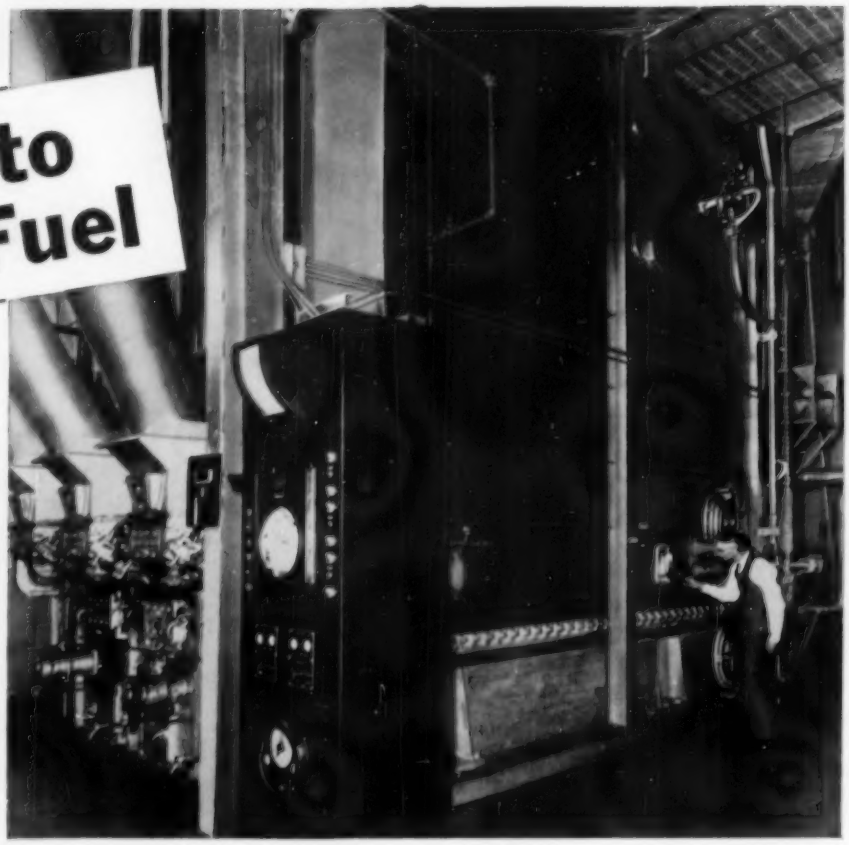
Internal boiler protection is but one phase of Dampney corrosion-control activity. Dampney Coating Systems for specified end-use service protect cooling towers — intake water structures — pipeline interiors. For a recommendation to meet your requirements, write

MAINTENANCE FOR METAL

THE DAMPNEY COMPANY

HYDE PARK, BOSTON 36, MASSACHUSETTS

How to Save Fuel



Fuel savings of 15% have resulted from steam plant modernization at General Mills, Inc., Buffalo, N. Y. The program included this installation of Bailey Meter Control on a 45,000 lb per hr, 170 psi spreader stoker-fired boiler.

The heat energy you get from a unit of fuel depends on the performance of your steam plant equipment. And that's where Bailey controls can help. With a Bailey-engineered control system you can count on a higher output of available energy per unit of fuel. Here's why:

1. Suitable Equipment

When you receive equipment recommendations from a Bailey Engineer his selections come from a complete line of well-engineered and carefully tested products.

2. Seasoned Engineering Experience

Your local Bailey Engineer brings you seasoned engineering experience based on thousands of successful installations involving problems in measurement, combustion, and automatic control.

3. Direct Sales-Service—close to you

For your convenience and to save time and travel expense there's a Bailey District Office or Resident Engineer in or close to your industrial community.

For greater fuel savings, less outage and safer working conditions, you owe it to yourself to investigate Bailey Controls. Ask a Bailey Engineer to arrange a visit to a nearby Bailey installation. We're glad to stand on our record. A-121-1

FORMULA
for Cutting
Production Costs
•
+ Bailey Design
+ Bailey Engineering
+ Bailey Service
= Greater Savings
per Fuel Dollar

BAILEY
METER COMPANY
1025 IVANHOE ROAD
CLEVELAND 10, OHIO
Complete Controls for Steam Plants

BAILEY METERS
Controls for
COMBUSTION
FEED WATER
TEMPERATURE
PRESSURE
LIQUID LEVEL
FEED PUMPS

BETTER COMPACTION... LOW COST STOCKPILING with EUCLID Twin-Power SCRAPERS

- Euclid Twin-Power Scrapers are doing a complete coal handling job for public utilities and industrial concerns . . . and they are doing a better, more efficient job than methods previously used.

Owners report that compaction of the stockpile is increased 10 to 15 lbs. per cubic foot by the heavy rubber-tired scrapers. This practically eliminates spontaneous combustion problems and provides a well drained stockpile.

The "Twin" is completely self-loading in loose, compacted, wet or frozen coal. It can work in very close quarters . . . carries big loads at speeds up to 30 m.p.h. . . . extends, raises or relocates the stockpile. It has proved to be the most economical solution to coal stockpiling and reclamation problems on many operations.

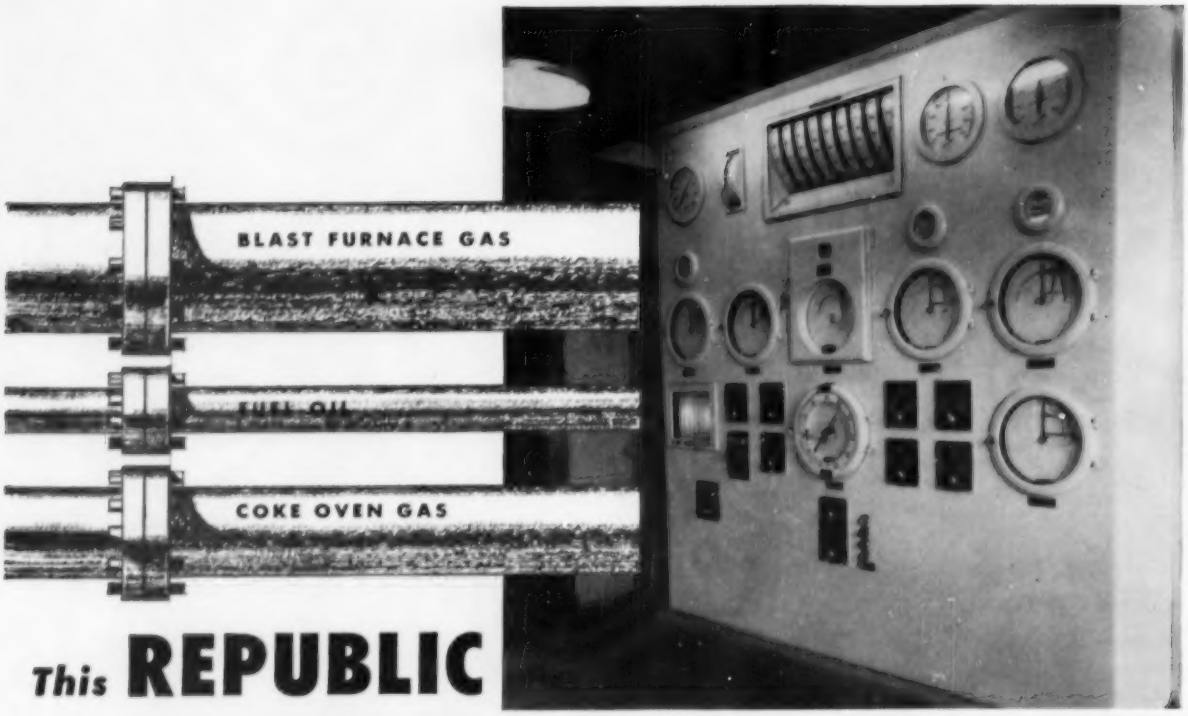
Your nearby Euclid distributor will prepare a production and cost estimate without obligation . . . have him show you how the "Euc" Twin-Power Scraper provides maximum flexibility with minimum investment and operating cost. Write for your copy of a new descriptive folder, Form 551A.

EUCLID DIVISION
GENERAL MOTORS CORPORATION
Cleveland 17, Ohio

Euclid Equipment

FOR MOVING EARTH, ROCK, COAL AND ORE

GM GENERAL MOTORS



Boiler panel at steel mill power plant includes subpanels and instruments for multi-fuel firing system. The boiler draft and fuel selection may be controlled manually from this panel, if desired.

This REPUBLIC COMBUSTION CONTROL SYSTEM

Automatically Selects Lowest Cost Combination of Three Available Fuels

Three fuels—blast furnace gas, coke oven gas, and fuel oil—are burned by three 125,000 lb. per hr. steam generating boilers at a large midwestern steel plant.

In addition to maintaining the proper fuel-air ratio and holding steam pressure constant at all loads, a Republic Control System automatically makes fuel selections according to the amount of by-product blast furnace gas available. At times when this low cost gas is plentiful, it is used as the primary fuel. The other two fuels are used only for make-up when available blast furnace gas cannot meet all of the fuel demand. If the blast furnace gas pressure falls below a predetermined minimum, however, flow is automatically reduced and one of the other two fuels also burned.

This dual purpose Combustion Control System cuts fuel costs two ways:

(1) Because of efficient combustion, less fuel is used for a given steam output.

(2) As much lowest cost fuel is used as possible.

Control Systems such as this one further illustrate how Republic engineers can design combustion controls that make the most of fuels available. Very likely, Republic can show *you* ways to get more power at less cost — automatically.

REPUBLIC AUTOMATIC COMBUSTION CONTROLS

★ For all types and sizes of boilers ★ For all types of fuel
★ For all types of firing
★ For all arrangements of draft ★ For all load conditions

REPUBLIC FLOW METERS CO.
2240 Diversey Parkway, Chicago 47, Illinois

Addressograph-Multigraph saves 29% in fuel costs burning coal the modern way

The Addressograph-Multigraph Corporation has a modern plant in suburban Cleveland. For economy and efficiency, the firm's boiler plant is coal-fired and boasts the latest in coal and ash handling equipment.

Coal offers many advantages to Addressograph-Multigraph. It is easy to handle. Only one man per shift is required to run the boiler plant on a 24-hour basis. There is no air pollution problem. And best of all is the low cost of operation! Coal costs 29.6% less than the next cheapest fuel and 35% less than the third one! With these benefits, no wonder Addressograph-Multigraph is a satisfied user of coal!

Investigate Your Fuel Costs

If you're planning to modernize your plant or build a new one—or if you are just interested in cutting fuel costs—find out how coal, burned the modern way, compares to other fuels. Talk to a consulting engineer or your nearest coal distributor. Their advice may save you thousands of dollars every year.

facts you should know about coal

In most industrial areas, bituminous coal is the lowest-cost fuel available.

Up-to-date coal burning equipment can give you 10% to 40% more steam per dollar.

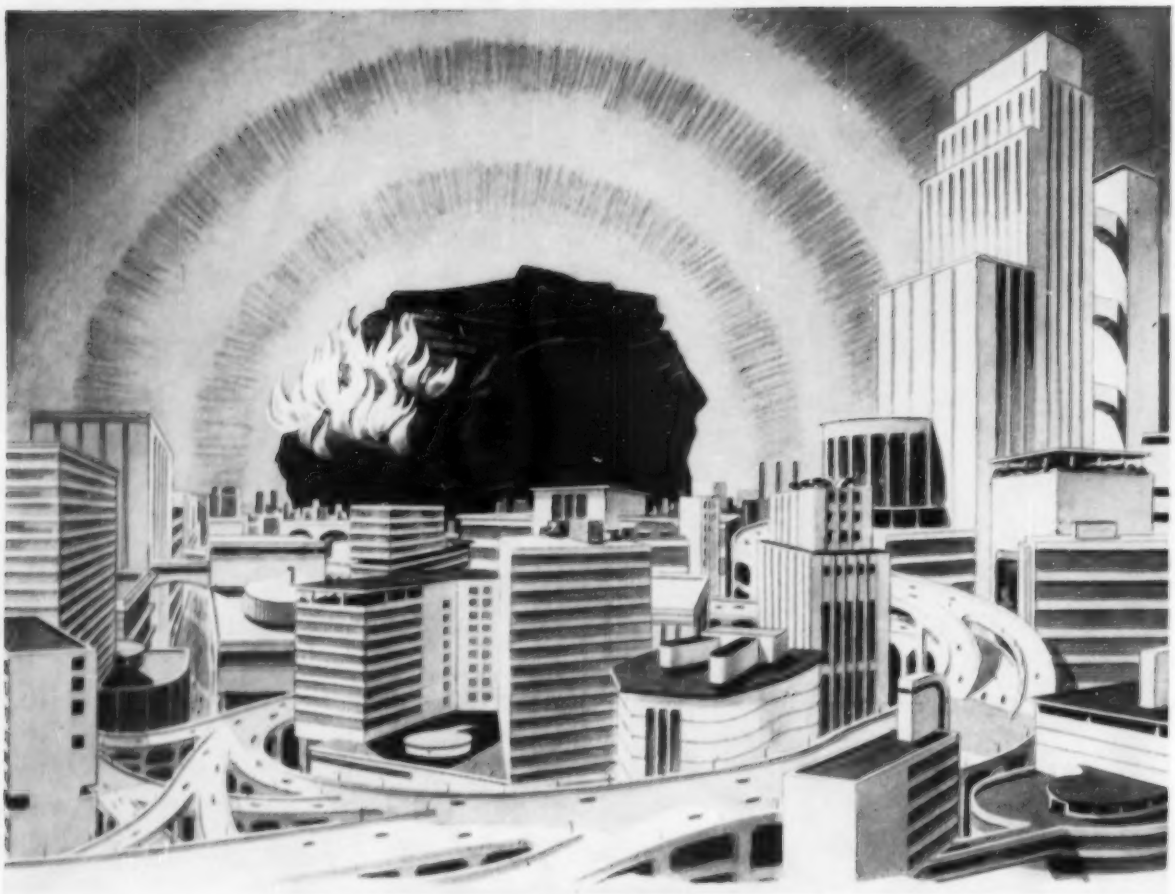
Automatic coal and ash handling systems can result in a virtually labor-free plant.

Coal is the safest fuel to store and use. No dust or smoke problems when coal is burned with modern equipment.

Between America's vast coal reserves and mechanized coal production methods, you can count on coal being plentiful and its price remaining stable.

For further information or additional case histories showing how other plants have saved money burning coal, write to the address below.

NATIONAL COAL ASSOCIATION
Southern Building, Washington 5, D.C.



The fuel that sparked our nation's growth secures her greater future

A young America—primed by a new and power-packed fuel—became a great industrial giant almost overnight. Coal had supplied the first unwavering spark which was to grow into the brightest productive flame the world has ever known.

After being served so well in the past and present, America looks again to dynamic coal for greater prosperity and security in the future. The vast Bituminous fields along the Baltimore & Ohio contain excellent coals in wide variety—available for centuries to come.

Highly mechanized mines, equipped and ready for any demands, will help maintain long-range cost stability. And improved utilization methods will meet the increased requirements of the future by providing greater coal-burning efficiency.

CALL ON OUR COAL TECHNICAL SERVICE

You'll receive complete information from trained B&O experts about the kind and size of Bituminous coal that fits your needs best—at a price you want to pay. Write:

COAL TRAFFIC DEPARTMENT
BALTIMORE & OHIO RAILROAD
BALTIMORE 1, MARYLAND

BITUMINOUS COALS FOR EVERY PURPOSE

Baltimore & Ohio Railroad

Constantly *doing things*—better!

WALWORTH

WALSEAL® VALVES AND FITTINGS

Better because . . . **There's no guesswork when a silver-brazed joint is made with a Walseal fitting. Sil-Fos alloy, which appears as a fillet at the face of a Walseal joint, comes from rings which have been factory-inserted in the end connections of Walseal fittings. The bright silver alloy fillet that you can see assures full penetration of alloy for a permanently leakproof joint.**

Cutaway view of a Walseal Tee showing: factory-inserted ring of silver brazing alloy; fillet of silver brazing alloy that appears upon completion of Walseal joint; cutaway view of the completed joint showing that silver brazing alloy has flowed in both directions from the factory-inserted ring.

Walseal is a registered trade mark identifying bronze valves and fittings manufactured by the Walworth Company. Walseal products have factory-inserted rings of silver brazing alloy in threadless ports. Walseal joints can be made only with Walseal valves and fittings.

If you're piping water, oil, steam, air, oxygen, nitrogen, helium or other industrial gases or refrigerants through brass, copper, or copper-nickel pipe, you'll want to investigate Walseal – available in complete lines of bronze valves and fittings in four distinct pressure ranges – from 0 to 5000 psi. working pressure*. Your copy of Circular 115 will be sent on request . . . see your near-by Walworth Distributor today, or write to: Walworth Company, General Offices, 60 East 42nd Street, New York 17, N. Y.

*Walseal fittings and valves are being used at sub-zero temperatures as low as —350 F.

Make it "a one-piece pipeline" with WALSEAL

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Manufacturers since 1842

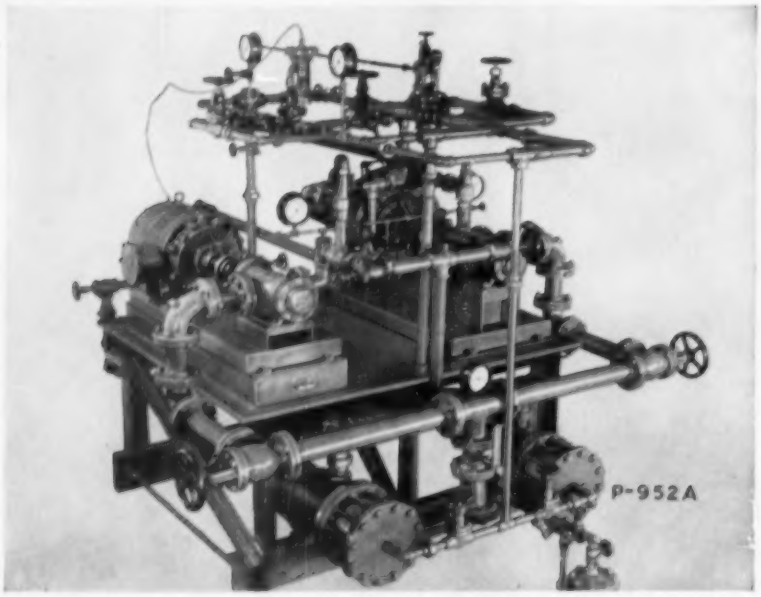
valves . . . pipe fittings . . . pipe wrenches

60 East 42nd Street, New York 17, N. Y.

DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD

Complete Range of Sizes and Models in Both Medium and High Pressure Types

MORE COMPACT THAN EVER..



P-952A—Steam Turbine and Electric Motor drive gives flexibility in this compact Model P-ES2H size No. 25 unit.

NATIONAL AIROIL

FUEL OIL PUMPING *AND* HEATING UNITS

NATIONAL AIROIL Fuel Oil Pumping and Heating Units are specially designed to prepare, for combustion, all grades of fuel oil including No. 6 or Bunker "C" Oil and residuums. They will draw fuel oil from above ground or underground tanks, preheat it to proper constant temperature and deliver it to Oil Burners at an even pressure, best suited for the burners. Our Fuel Oil Pumping and Heating Units are the result of years of experience. They come completely equipped ready for steam, exhaust, condensate, oil suction, oil return, and electrical connections. All valves, regulators, etc., are readily accessible. The piping arrangement is easily understood. These compact, space-saving units are available in a range of sizes and models in both Medium and High Pressure types. For complete details, write for our Bulletin 40—very interesting and informative.

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STEAM ATOMIZING OIL BURNERS
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- Saving Installation Time
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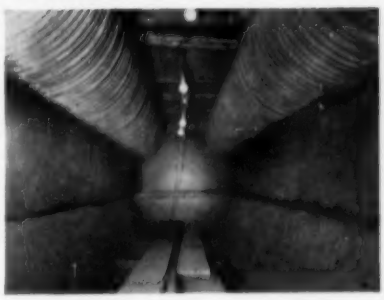
HERE'S MOLDIT—the most successful line of hydraulic setting castable refractory materials for the greatest range of industrial heating applications.

WITH MOLDIT—mixed as ordinary concrete—you pour, cast or gun your own refractories in any size and shape, fast. No high-cost inventory of special shapes to maintain.

MOLDIT OUTLASTS THE REST. Air-sets, without prefiring, to full refractory hardness. More resistant to thermal shock and abrasion.

PLANTS REPORT SAVINGS up to 90% in repair and maintenance costs when Moldit Castables replace other refractories.



Ashpit of large coal-fired boiler completely "gunned" with R&I Moldit. Records show not a single repair required in 11 years of constant service in a number of ash hoppers lined with Moldit.

Gunning a 5½" thickness of Moldit Chrome Refractory on a boiler floor for maximum resistance to molten slag at 2750° to 2850° F. Such floors have been in service for 6 and 7 years without a failure.

Moldit Castable Refractories

R&I

REFRACTORY CASTABLE AND BONDING CEMENTS

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INSULATING BLOCK, BLANKETS AND CEMENTS

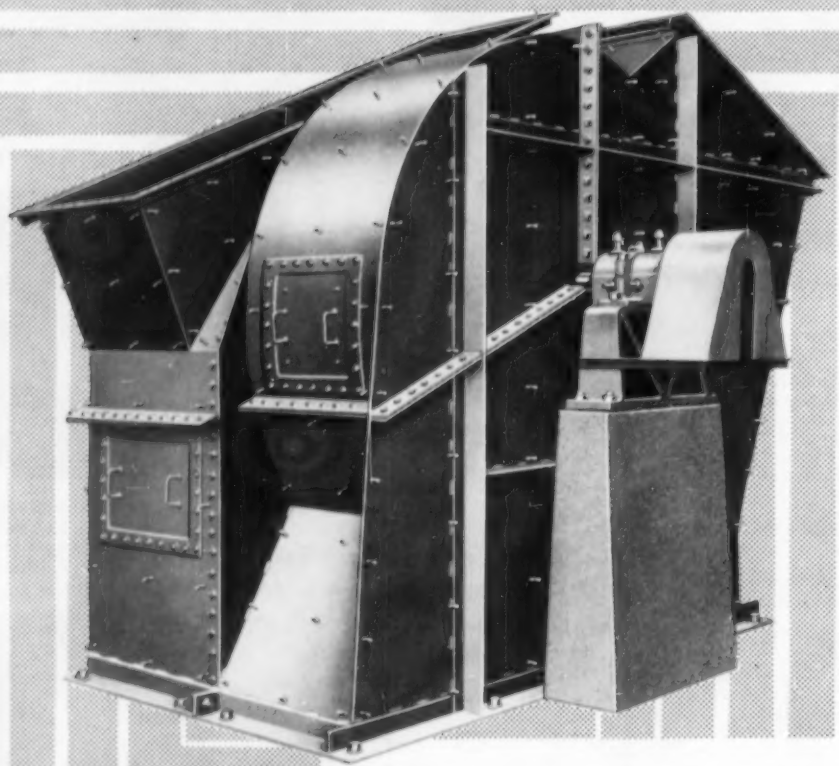
FOR EVERY REQUIREMENT

Send for catalog on 10 different Moldit Refractory and Insulating Refractory Castables. Also get the story on R&I Super #3000, the truly "wonder" refractory bonding mortar.

REFRACTORY & INSULATION CORPORATION

124 Wall Street • New York 5, N. Y.

Over 3000 power plants are Clarage equipped



With mechanical draft fans especially, first cost is not the major consideration. Economy is measured by your investment over the long pull.

That's why Clarage fans enjoy such a high standing in power production. Here's equipment designed and constructed to take punishment in stride. Wheels, shafts, housings, bearings — all are built **above and beyond** the demands of average service.

You can install Clarage equipment with confidence that operating and maintenance costs will be at an absolute minimum. Hundreds of Clarage fans in continuous service for 30 years and longer testify to that!

Have us put the facts in your hands. Request catalogs on Clarage Type RT induced and forced draft fans . . . Type W, Classes III and IV forced draft fans . . . Type NH, Class II-A forced draft fans. **CLARAGE FAN COMPANY, Kalamazoo, Michigan.**

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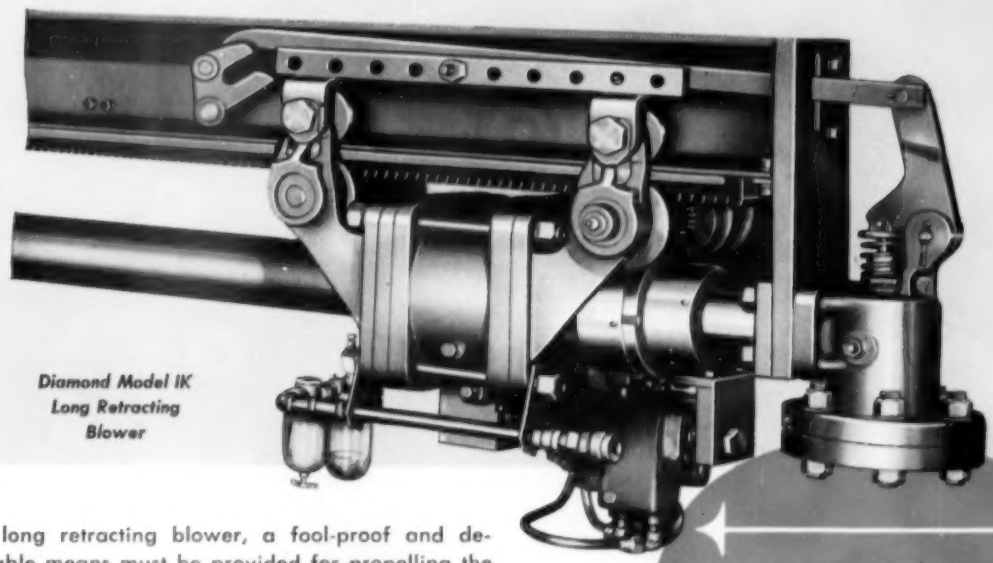
One of a Series

Reasons Why DIAMOND BLOWERS Assure CLEANER BOILERS *at LOWER COST*

SINGLE MOTOR DRIVE



Diamond Model IK Long Retracting Blower

A Single Motor (air or electric) Both Rotates and Propels the Long Lance Tube

In a long retracting blower, a fool-proof and dependable means must be provided for propelling the carriage and rotating the lance tube. In Model IK it is done with a SINGLE MOTOR working through a simple system of rugged gears. The operating mechanism is a model of simplicity and reliability . . . only one set of motor elements, one set of control elements . . . one set of power supply facilities to operate and maintain. This drive produces a closely pitched helical cleaning pattern which is most effective for *all* deposits and tube banks . . . without tube cutting.

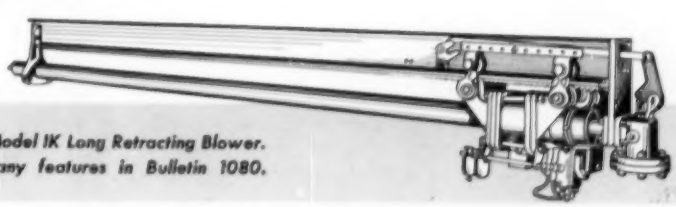
Other features which users approve with enthusiasm are the mechanically operated valve with adjustable pressure control, and the positive gear drive. Ask for Bulletin 1080V.

DIAMOND POWER SPECIALTY CORP.

LANCASTER, OHIO

Diamond Specialty Limited, Windsor, Ontario

6776



Diamond Model IK Long Retracting Blower. See its many features in Bulletin 1080.

40 PAGES of helpful information

on Recovering Dusts, Fly Ash, Mists, Fumes and other Suspensions from Gases.

This booklet summarizes
the important points design and plant engineers should know about Cottrell Precipitators . . .

- Basic types of Cottrell equipment.
- Principal elements in a Cottrell unit.
- Data on Mechanical and Electronic Rectifiers.
- Various types of Collecting Electrodes (rod curtains, corrugated plates, pocket electrodes, etc.).
- Typical ways of removing collected material.
- Various Shell Constructions (steel, concrete, brick, etc.).
- The effect of various factors on efficiency and performance.
- Data on CMP (Combination Multiclone-Precipitator) Units.

. . . and many other helpful facts on Cottrell design and operation.

Latest data from Western Precipitation on Cottrell Recovery Equipment

Do you have operations in your plant where gas-laden suspensions, wet or dry, are a problem? Such suspensions may be dropping on surrounding property, causing nuisance difficulties. Or perhaps important values are being lost in stack gases that can be profitably recovered. Whatever the nature of your recovery requirements, you will find this 40-page Cottrell booklet of great help. It contains up-to-date data on the latest advancements in the electrical precipitation field – prepared by the organization that pioneered the commercial application of Cottrell Electrical Precipitators almost a half century ago and has consistently led in new Cottrell developments.

A copy of this data-packed booklet will be sent free to engineers and other executives interested in recovery processes. Send your request to our nearest office.

For nearly 30 years Western Precipitation has carried on a continuous research and development program on Cottrell Electrical Precipitators, Multiclone Mechanical Collectors and other types of recovery equipment. We are not affiliated with any other company in the electrical precipitation field except our wholly owned subsidiaries, International Precipitation Corporation and the Precipitation Company of Canada, Ltd. We are equipped to serve you anywhere in the United States, Canada, and throughout the world!

WESTERN Precipitation CORPORATION

DESIGNERS AND MANUFACTURERS OF EQUIPMENT FOR COLLECTION OF SUSPENDED MATERIALS FROM GASES & LIQUIDS

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